

A Study of the Behavior of the
Brittle Lacquer Commercially Known
as Stresscoat When Subjected to
Biaxial Stress of a Known Intensity
and Configuration

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January 16, 1948



Cambridge, Massachusetts
January 16, 1948

Professor J. S. Newell,
Secretary of the Faculty,
Massachusetts Institute of Technology,
Cambridge, Massachusetts .

Dear Sir:

In accordance with the requirements for the Degree of Master of Science in Naval Construction and Engineering, we submit herewith a thesis entitled "A Study of the Behavior of the Brittle Lacquer Commercially Known as Stresscoat When Subjected to Biaxial Stress of Known Intensity and Configuration."

Respectfully,

Respectfully,

Intensity and Configuration."

Stresscoat When Subjected to Static Stresses of Known
Behavior of the Brittle Ladings Commonly Known as
we submit herewith a thesis entitled "A Study of the
of Master of Science in Naval Construction and Engineering.
In accordance with the requirements for the degree

Very truly:

Professor L. E. Merrill,
Secretary of the Faculty,
Massachusetts Institute of Technology,
Cambridge, Massachusetts.

Cambridge, Massachusetts
January 18, 1948

A STUDY OF THE BEHAVIOR OF THE BRITTLE LACQUER COMMERCIALLY
KNOWN AS STRESSCOAT WHEN SUBJECTED TO BIAXIAL STRESS OF A
KNOWN INTENSITY AND CONFIGURATION

By

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Submitted in partial fulfillment of the
requirements for the degree of
MASTER OF SCIENCE IN NAVAL CONSTRUCTION AND ENGINEERING
at the
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

1948

A STUDY OF THE BEHAVIOR OF THE SELECTED LANTHAN COMPOUNDS
 KNOWN AS INTERCALATION WHEN SUBJECTED TO VARIOUS TYPES OF A
 KNOWN INTENSITY AND DIRECTION

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Thesis
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APPENDIX

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and indebtedness to the following persons:
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apparatus.

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TABLE OF SYMBOLS

- e_a - Average axial strain in specimen obtained from strain gauges, micro inches/inch.
- e_c - Average circumferential strain in specimen obtained from strain gauges, micro inches/inch.
- e_{max} - Average maximum strain in the specimen obtained from strain gauges, micro inches/inches.
- e_{min} - Average minimum strain in the specimen obtained from strain gauges, micro inches/inch.
- e - Lateral strain in the calibration bar. - vE - micro inches/inch.
- E_a - Average axial strain in specimen obtained from strain gauges and corrected for lateral sensitivity, micro inches/inch.
- E_c - Average circumferential strain in specimen obtained from strain gauges and corrected for lateral sensitivity, micro inches/inch.
- E_{max} - Average maximum strain in specimen corrected for lateral sensitivity, micro inches/inch.
- E_{min} - Average minimum strain in specimen corrected for lateral sensitivity, micro inches/inch.
- E - Average longitudinal strain determined from several calibration bars, micro inches/inch.
- E_m - Young's Modulus.
- t - Time of loading specimen, seconds.
- T_d - Temperature of coating surface during test, deg. F.
- $S\#$ - Number of particular grade of Stresscoat used.
- D - Deviation or $E - E_{max}$, micro inches/inch.
- $\%D$ - Percent deviation or $(100) (E - E_{max}) / (E_{max})$, %.
- $\%D_s$ - Percent stress deviation, $(S_{bar} - S_{max}) (100) / S_{max}$.

TABLE OF SYMBOLS

ϵ_a	- Average axial strain in specimen obtained from strain gages, micro inches/inch.
ϵ_c	- Average circumferential strain in specimen obtained from strain gages, micro inches/inch.
ϵ_{max}	- Average maximum strain in the specimen obtained from strain gages, micro inches/inch.
ϵ_{min}	- Average minimum strain in the specimen obtained from strain gages, micro inches/inch.
ϵ	- Lateral strain in the calibration bar. - ϵ_L - micro inches/inch.
ϵ_a	- Average axial strain in specimen obtained from strain gages and corrected for lateral sensitivity, micro inches/inch.
ϵ_c	- Average circumferential strain in specimen obtained from strain gages and corrected for lateral sensitivity, micro inches/inch.
ϵ_{max}	- Average maximum strain in specimen corrected for lateral sensitivity, micro inches/inch.
ϵ_{min}	- Average minimum strain in specimen corrected for lateral sensitivity, micro inches/inch.
E	- Average longitudinal strain determined from lateral calibration bars, micro inches/inch.
E_m	- Young's modulus.
t	- Time of loading specimen, seconds.
T_f	- Temperature of coating surface during test, deg. F.
Δ	- Number of articulation grade of stresscoat used.
D	- Deviation of $E - E_{max}$, micro inches/inch.
$\%E$	- Percent deviation of (100) $(E - E_{max}) / (E_{max})$, %.
$\%D$	- Percent stress deviation, $(200 - 2max) / (100 - 2max)$.

TABLE OF SYMBOLS

- S_{max} - Maximum stress in the specimen, psi.
- S_{min} - Minimum stress in the specimen, psi.
- S_{bar} - Stress indicated by calibration bar, psi.
- v - Poisson's ratio.
- v_o - Poisson's ratio of steel on which strain gauges were calibrated, .285.
- k - A constant with value of .021 for type A-3 strain gauges.

TABLE OF RESULTS

- 1 - Maximum stress in the specimen, psi.
- 2 - Minimum stress in the specimen, psi.
- 3 - Stress indicated by calibration bar, psi.
- 4 - Poisson's ratio.
- 5 - Poisson's ratio of steel on which strain gauges were calibrated, .285.
- 6 - A constant with value of .001 for type A-J strain gauges.

SUMMARY

Results

It was found that more strain was required to produce a crack pattern under tensile load than was indicated by the calibration bar. The opposite effect was observed when the specimen was subjected to internal pressure. The presence of crazing decreased the sensitivity of Stresscoat. The presence of a strain crack pattern in one direction has a yet unexplained effect on the sensitivity of Stresscoat to failure in a perpendicular direction.

Object

The purpose of this investigation was to expand the limited knowledge of the behavior of Stresscoat when subjected to a biaxial stress condition different from that stress condition existing in the calibration bar and to correlate the information obtained in such a manner that more precise quantitative determinations are possible. For the benefit of future experimenters in this field an attempt was made to analyze any peculiarities in the behavior of the Stresscoat which were observed.

Procedure

The actual strain on the surface of a hollow cylindrical test specimen was determined with strain gauges when the surface of the vessel was subjected to different combinations of two-dimensional strain. These combinations of strain were produced by applying axial loading and internal pressure to the specimen. The strains causing a crack

Results

It was found that when strain was permitted to produce a crack certain water tensile load then was indicated by the calibration bar. The opposite effect was observed when the specimen was subjected to internal pressure. The presence of existing defects and the sensitivity of measurement. The presence of a strain crack pattern in one direction and a yet unexplained effect on the sensitivity of measurement. to failure in a perpendicular direction.

Object

The purpose of this investigation was to provide a limited knowledge of the behavior of specimens when subjected to a biaxial stress condition. It was found that stress condition existing in the calibration bar and in the points the information obtained in such a manner that more precise quantitative determinations are possible. For the benefit of future experiments in this field an attempt was made to analyze any possibilities in the behavior of the specimens which were observed.

Procedure

The actual strain on the surface of a hollow cylinder and total specimen was determined with strain gauges when the surface of the vessel was subjected to different combinations of two-dimensional strain. These combinations of strain were produced by applying water tension and internal pressure to the specimen. The strain gauges were attached

SUMMARY

pattern in the Stresscoat applied to the test specimen in the vicinity of the strain gauges were compared with the strains indicated by the calibration bars.

Conclusion

The deviation between actual strain and the strain indicated by the Stresscoat may vary from zero to thirty percent depending upon the ratio of minimum strain to the maximum strain in the specimen. When strain, indicated by Stresscoat, is used to calculate stress the deviation between actual stress and calculated stress is reduced to a maximum value of approximately fifteen percent.

Recommendations

Further investigation of the behavior of Stresscoat should be conducted under controlled atmospheric conditions. Apparatus should be designed by which axial load and internal pressure may be applied uniformly and simultaneously to the specimen, to facilitate handling the creep characteristic of Stresscoat at all values of S_{min}/S_{max} . Evaluation of Poisson's ratio and the modulus of elasticity of Stresscoat, combined with the values of strain for various values of S_{min}/S_{max} would allow the determination of the theory of failure of Stresscoat.

appears in the stress-strain curve. The deviation in the vicinity of the origin is very small and the deviation indicated by the origin is very small.

Conclusions

The deviation between actual strain and the strain indicated by the stress-strain curve may vary from zero to fifty percent depending upon the ratio of strain rate in the stress-strain curve to the strain rate in the stress-strain curve. It is used to calculate the deviation between actual stress and calculated stress is reduced to a maximum value of approximately fifteen percent.

References

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2. The effect of strain rate on the behavior of stress-strain curves in compression.
3. The effect of strain rate on the behavior of stress-strain curves in compression.
4. The effect of strain rate on the behavior of stress-strain curves in compression.
5. The effect of strain rate on the behavior of stress-strain curves in compression.
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8. The effect of strain rate on the behavior of stress-strain curves in compression.
9. The effect of strain rate on the behavior of stress-strain curves in compression.
10. The effect of strain rate on the behavior of stress-strain curves in compression.

INTRODUCTION

Stressecoat is the latest widely known development in the field of brittle coatings used for stress-strain analysis of the component parts of structures. When a base material is subjected to a progressively increasing stress, the distortion in the base material will eventually cause any brittle coating adhering to its surface to fail by cracking. In most coats these cracks occur in a direction perpendicular to the direction of the principal stress. If the base material is subjected to such large stresses that its yield point is exceeded and very large amounts of distortion occur, the brittle coating will flake or spawl off. One of the early observed instances of this phenomenon was the cracking or flaking off of mill scale on structural members under load. The places in the structure where this breakdown of scale first occurred were points of weakness or stress concentration. Early investigators also noticed that the presence of a coat of white-wash on structural members increased the ease with which a failure in the mill scale could be observed. Cracking and spawling of bitumastic enamel used on shipboard was another early example of this phenomenon. Attempts to utilize these observations for quantitative measurements were unsuccessful.

The search for a brittle coating which would be capable of dependable quantitative, as well as qualitative, interpretation continued in the United States and other countries (principally Great Britain and Germany). Many substances

CITIZENSHIP

The search for a bridge crossing which would be suitable for the purpose of the investigation, as well as for the purpose of the investigation, was not successful. The search for a bridge crossing which would be suitable for the purpose of the investigation, as well as for the purpose of the investigation, was not successful. The search for a bridge crossing which would be suitable for the purpose of the investigation, as well as for the purpose of the investigation, was not successful.

such as sugar, sulphur, plaster of Paris, and various resins were tried. The late Professor A. V. DeForest of Massachusetts Institute of Technology did considerable preliminary work which contributed to the final development of the present day Stresscoat. He tried various methods of coating application as well as types of material for the coating itself. The methods of application investigated were:

- a. Covering the surface with powdered material which was subsequently heated until it melted to form a continuous coat.
- b. Brushing, dipping, or spraying the molten coating on the base material.
- c. Brushing, dipping, or spraying the coating, dissolved in a solvent which evaporates as the coating assumes its brittle condition.

Mr. Greer Ellis (8) in 1937 determined the composition of a brittle lacquer having those characteristics which made it ideal for qualitative and quantitative strain indicating. The desirable characteristics are:

- a. Ability to fail by cracking due to strains within the elastic range of most engineering materials.
- b. Crack sensitivity fairly independent of coat thickness.
- c. Ability to dry to brittleness, within a reasonable length of time and at normal temperatures.
- d. Appearance of cracks should be easily discernible.

such as sugar, rubber, plaster of Paris, and various resins were tested. The late Professor A. V. Bennett of Massachusetts Institute of Technology did a considerable preliminary work which contributed to the final development of the present day processes. He tried various methods of coating application as well as types of material for the coating itself. The methods of application investigated were:

- a. Covering the surface with powdered material which was subsequently heated until it melted to form a continuous coat.
- b. Brushing, dipping, or spraying the molten coating on the base material.
- c. Brushing, dipping, or spraying the coating dissolved in a solvent which evaporates on the cooling, leaving the brittle condition.

Mr. West (5) in 1937 determined the composition of a brittle lacquer having these characteristics which made it ideal for qualitative and quantitative strain indicating.

The desirable characteristics are:

- a. Ability to fail by cracking due to strains within the elastic range of most engineering materials.
- b. Crack sensitively fairly independent of coat thickness.
- c. Ability to dry to brittleness within a reasonable time of time and at normal temperatures.
- d. Appearance of cracks should be easily discernible.

This brittle lacquer is currently known, commercially, as Stresscoat. It is manufactured and distributed by the Magnaflux Corporation. It is excellent for qualitative experimentation and the manufacturer claims that quantitative results obtained from tests conducted under controlled loading and atmospheric conditions are accurate within about 10%.

A calibration bar is employed to interpret the results obtained when using Stresscoat. The bar is secured at one end only in a jig so that it approximates a cantilever beam. The specimen under investigation and the calibration bar are sprayed and dried under identical conditions. After drying, the specimen is stressed and the free end of the calibration bar is depressed a known amount in the jig. This produces a known stress and strain in the bar varying from zero at the free end to a maximum value at the fixed end. Cracks appear in the Stresscoat over that portion of the bar in which the strain exceeds the value which will cause failure in the particular coating involved. Current practice is to assume that the strain under the last crack toward the free end of the bar is the same strain which exists under the first crack to appear in the Stresscoat on the specimen. The validity of this assumption is open to question because the calibration bar is subjected to uniaxial stress with a constant ratio between the principal strains produced; while a material under investigation may be subjected to any of an unlimited number of biaxial stress conditions, each causing a particular combination of two or three dimensional strains.

This drift lacquer is currently known, commercially, as
Dyresol. It is manufactured and distributed by the
Dyresol Corporation. It is excellent for qualitative ex-
amination and the manufacturer claims that qualitative
results obtained from tests conducted under controlled condi-
tions and atmospheric conditions are accurate within about 10%.
A calibration bar is employed to insure the results
obtained when using Dyresol. The bar is marked at one
end only in a jig so that it approximates a cylindrical bar.
The specimen under investigation and the calibration bar are
exposed and dried under identical conditions. After drying,
the specimen is removed and the bar is placed at the calibration
bar is fastened a known amount in the jig. This produces
a known stress and strain in the bar varying from zero at
the free end to a maximum value at the fixed end. Cracks
appear in the Dyresol over that portion of the bar in
which the strain exceeds the value which will cause failure
in the particular coating involved. Current practice is to
measure the strain under the load from toward the free
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constant ratio between the principal strains produced; while
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unlimited number of biaxial stress conditions, each causing
a particular condition of two or three dimensional strains.

Only a limited amount of work investigating the behavior of Stresscoat under biaxial stress has been done and very little has been published. Eric Olsen (11) in 1941 investigated the accuracy of quantitative Stresscoat determinations when the specimen was subjected to a two-dimensional strain condition different from that existing in the calibration bar for a few specific two-dimensional strain conditions. It is the aim of this report to further develop the investigation in this field by conducting enough consecutive tests in each of a few particular conditions of two-dimensional strain so that some knowledge of the magnitude of the deviation between the calibration bar indicated strain and the actual strain in the specimen may be learned.

During the course of the experiments various peculiarities of the general behavior of Stresscoat were observed. Although this information was secondary to the original purpose of the investigation it has been recorded and discussed because it was felt that it may be of value to those who will continue with further work in this field.

Only a limited amount of work investigating the behavior of the organism under physical stress has been done and very little has been published. This class (II) in 1941 investigated the accuracy of quantitative responses to stimuli when the organism was subjected to a two-dimensional strain condition different from that existing in the calibration bar for a few specific two-dimensional strain conditions. It is the aim of this report to further develop the investigation in this field by obtaining accurate comparative tests in each of a few particular conditions of two-dimensional strain so that some knowledge of the magnitude of the deviation between the calibration bar indicated strain and the actual strain in the specimen may be learned. During the course of the experiments various modifications of the general behavior of the organism were observed. Although this information was secondary to the original purpose of the investigation it has been recorded and discussed because it was felt that it may be of value to those who will continue with further work in this field.

PROCEDURE

The first step in the investigation was to select a test specimen in which at least two different conditions of biaxial stress could be set up. The specimen used was a thin walled tube of low carbon steel which was made into a pressure vessel by welding forged plugs into each end. The outboard ends of these plugs were machined to fit a self centering attachment on the tensile testing machine used. The end plugs were drilled and tapped to receive high pressure copper tube and fittings for applying the internal pressure to the test specimen. Four SR-4 electric strain gauges were affixed at equal intervals around the outside of the tube far enough from the ends to eliminate end effects. Two of these strain gauges were circumferential and two were axial. The gauges in the same direction were placed on opposite sides of the specimen. The dimensions and composition of the specimen were chosen to give strains applicable to Stresscoat investigation, within the elastic limits of the material and the capacity of the loading devices.

The second step was the mastery of Stresscoat and strain gauge technique. About six weeks were consumed before it was felt that enough proficiency had been gained in applying Stresscoat, controlling conditions during the drying and testing, and observing the first cracks to produce reliable data. During the early part of this educational period, an attempt was made to learn by experience, but the

The first step in the investigation was to select a test specimen in which at least two different conditions of biaxial stress could be set up. The specimen used was a thin walled tube of low carbon steel which was made into a pressure vessel by welding formed flange into each end. The outboard ends of these flanges were machined to fit a self centering attachment on the tensile testing machine used. The end flanges were drilled and tapped to receive high pressure copper tube and fittings for applying the internal pressure to the test specimen. Four BX-4 electric strain gauges were affixed at equal intervals around the outside of the tube far enough from the ends to eliminate end effects. Two of these strain gauges were circumferential and two were axial. The gauges in the same direction were placed on opposite sides of the specimen. The dimensions and composition of the specimen were chosen to give strains applicable to stress-strain investigation, within the elastic limits of the material and the capacity of the loading device.

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detailed instructions published by the manufacturer (16) were carefully studied prior to taking the data incorporated in this report. Such a course was considered to be most conducive to observing as many of the characteristics of Stresscoat as possible. The Stresscoat was applied in a special spray booth in the basement of the Institute and the drying took place in the DeForest Memorial Stress Laboratory. The pressure runs were also made in the Stress Laboratory, but the tensile runs were made in the Material Testing Laboratory of the Institute.

Anticipation of atmospheric conditions, which would exist twelve to twenty-four hours after the application of the coat, was required in choosing the proper grade of lacquer. The grade chosen should fail at a practical value of strain, but should not be so sensitive as to craze during the drying period. The choice was made with the aid of a chart provided by the manufacturer. Difficulty was encountered in obtaining sufficient sensitivity for the tensile runs without the occurrence of crazing due to the large and rapid fluctuation of the temperature in the Institute during the night. This problem was defeated by covering the specimen and calibration bars with a large cardboard enclosure during the drying period. A lighted electric bulb inside this enclosure served to keep the coatings at a sufficiently high temperature to prevent crazing. Several times it was necessary to artificially cool the coatings in order to obtain cracking at a practical value of strain. The specimen

Detailed instructions supplied by the manufacturer (10) were carefully studied prior to testing the data recorded in this report. Each a course was considered to be most conducive to deriving as many of the characteristics of the process as possible. The phenomenon was limited in a special way both in the presence of the liquid and the drying took place in the special special drying laboratory. The pressure was also made in the drying laboratory, but the results were made in the special drying laboratory at the Institute.

Amplification of atmospheric conditions, which would exist twice to twenty-four hours after the application of the coal, was required in special cases. The grade chosen would be at a practical value of course, but known not to be excessive in its value during the drying period. The choice was made with the aid of a chart provided by the manufacturer. Difficulties were encountered in obtaining sufficient sensitivity for the results. Time when the occurrence of drying was to be large and rapid fluctuation of the temperature in the Institute during the night. This problem was solved by covering the special and calibration data with a large number of enclosures during the drying period. A limited amount of this data was necessary to give the results as a satisfactory high resolution to prevent staining. Several times it was necessary to artificially cool the system in order to obtain drying at a practical value of strain. The results

and the calibration bars were maintained at the same constant temperature during each test.

Although an attempt was made to load the specimen in as short a time as possible, the time of loading varied from thirty seconds to three minutes. The creep of the coating during a finite loading time was an additional important variable. As the time of loading increases the sensitivity of the coat decreases. If the time of loading is long enough, formation of the crack pattern may never occur. This creep phenomenon must be considered if the correct interpretation of the test results is to be obtained. This is accomplished either by loading the calibration bars gradually in the same period of time as the specimen was loaded or by loading the calibration bars in one second and then applying a creep correction factor. This correction is made by utilizing the creep correction charts furnished by the manufacturer. Six calibration bars were used for each run and three were loaded in each of the ways described above.

The pressure runs were made with the specimen freely supported by the ends in a wooden cradle. The hydraulic pump, used to supply the water pressure internally to the specimen, was of the jack type. It was equipped with a pressure gauge which allowed a rough estimate of the internal pressure, and also permitted us to control the rate of load application. The tensile or axial loading runs were made by pulling the specimen in a conventional tensile

and the calibration data were maintained as the same constant temperature during each test.

Although an attempt was made to load the specimen in as short a time as possible, the time of loading varied from thirty seconds to three minutes. The stress of the coating during a finite loading time was an additional important variable. As the time of loading increased the sensitivity of the coat decreases. If the time of loading is long enough, formation of the crack pattern may never occur. This stress phenomenon must be considered if the correct interpretation of the test results is to be obtained. This is accomplished either by loading the calibration bars exactly in the same period of time as the specimen was loaded or by loading the calibration bars in one second and then applying a stress correction factor. This correction is made by utilizing the stress correction curve furnished by the manufacturer. Six calibration bars were used for each run and three were loaded in each of the ways described above.

The pressure runs were made with the specimen freely supported by the rods in a wooden cradle. The hydraulic pump, used to supply the water pressure internally to the specimen, was of the jack type. It was supplied with a pressure valve which allowed a rough estimate of the internal pressure, and also operated as a control for rate of load application. The loading of metal loaded bars was made by pulling the specimen in a conventional fashion.

testing machine. The pressure gauge and the beam balance readings were not essential to the data as the strain gauges provided the actual strains on the surface of the specimen. It was necessary to correct for lateral sensitivity of the SR-4 strain gauges.

A total of twenty-seven runs were made on the test specimen, but the data of runs seventeen through twenty-seven was considered to be that which represented the best technique, and consequently only these eleven runs were used.

It was considered of interest to investigate the effect of the presence of severe crazing on the behavior of the Stresscoat. An experiment was attempted using six calibration bars, three of which were artificially crazed by exposure to a low temperature for a short period of time, while the other three were maintained with a clear coat. The bending test was applied to these bars after all six of them had returned to the same temperature and had remained at that temperature for about one-half of an hour. Time loading of these bars was used because the progress of the cracks could be followed on the crazed bars with more ease and accuracy than would be the case if a one second load were applied.

After each tensile crack pattern had been formed on the specimen, and an interval of time exceeding twice the time during which the load was applied and held had elapsed, the specimen was subjected to a pressure run. The results

testing machine. The pressure gauge and the beam balance readings were not essential to the data on the strain gauge provided the actual strain on the surface of the specimen. It was necessary to correct for lateral sensitivity of the strain gauge.

A total of twenty-seven runs were made on the test specimen, but the data of runs numbered through twenty-seven was considered to be that which represented the best technique, and consequently only these eleven runs were used.

It was considered of interest to investigate the effect of the presence of water existing on the bottom of the specimen. An experiment was attempted using the oil-bath test, three of which were artificially created by exposing to a low temperature for a short period of time, while the other three were maintained with a clear test. The machine was cooled to these temperatures and after all of them had returned to the same temperature and had remained at that temperature for about one-half of an hour. The loading of these runs was made because the presence of the cracks could be followed on the strain gauge after more tests and accuracy than could be obtained if a one second test were applied.

After each test the crack pattern had been formed on the specimen, and an interval of time exceeding twice the time during which the load was applied was left and elapsed, the specimen was subjected to a pressure test. The results

of these runs indicated the desirability of further investigation of the nature of cracking of Stresscoat in a direction perpendicular to cracks already produced on the specimen by a previous test. Therefore, a fifteen inch square of celluloid one-eighth of an inch thick was coated with Stresscoat. After drying, this flat plate was secured by one edge in a cantilever fashion and the opposite edge was depressed a certain distance in a given length of time. After allowing time for the creep recovery of the Stresscoat, the plate was turned ninety degrees and the identical experiment was repeated. The nature of the total crack pattern was then observed.

An investigation of the conformance of the calibration bar to beam theory and Poisson's ratio effect was made by checking the lateral strain at various points along the bar with SR-4 strain gauges.

The strain gauge readings and axial load or internal pressure at the appearance of the first crack in the coating on the specimen were recorded. The strain corresponding to the last crack on the calibration bars was taken as the calibrating strain. A flash light focused perpendicular to the anticipated direction of the cracks was a necessary aid in catching the first crack. The actual strains were compared with those indicated by the calibration bar. The deviations of the calibration bar strain from actual strain for the pressure and tensile runs were compared. For the tests involving the calibration bars alone the results occurring

of these points indicated the desirability of further investigation of the nature of cracking of concrete in a direction perpendicular to cracks already produced on the specimen by a previous test. Therefore, a fifteen inch square of reinforced concrete of an inch thick was coated with glass paint after drying, this last plate was secured by one edge in a cantilever fashion and the opposite edge was secured at a certain distance in a given length of plate. After allowing time for the glass recovery of the specimen, the plate was turned ninety degrees and the identical experiment was repeated. The nature of the total crack pattern was then observed.

In investigation of the characteristics of the calibration bar to determine energy and Watson's ratio effect was made by checking the lateral strain at various points along the bar with a strain gauge.

The strain gauge readings and lateral load are indicated graphically at the upper part of the first figure in the coupling on the specimen were recorded. The strain corresponding to the load crack on the calibration bar was taken as the calibration strain. A strain gauge located perpendicular to the anticipated direction of the crack was a necessary aid in obtaining the first crack. The actual strains were compared with those indicated by the calibration bar. The deviations of the calibration bar strain from actual strain for the specimens and bearing the same were compared. For the same investigation the calibration bars along the vertical covering

under different types of treatment were compared. All comparisons were straight forward and involved no complicated computations.

For a detailed description of the equipment used see Appendix A.

under different types of treatment were compared. All com-
parisons were slightly forward and involved no complicated
computations.

For a detailed description of the procedure used see

Appendix A.

The first part of the study was a pilot study to determine
the feasibility of the procedure. This was done by comparing
the results of the procedure with those of a standard procedure.
The results of the pilot study showed that the procedure was
feasible and that the results were comparable to those of the
standard procedure. The results of the pilot study are shown
in Table 1. The results of the pilot study are shown in
Table 1. The results of the pilot study are shown in Table 1.

The second part of the study was a comparison of the
results of the procedure with those of a standard procedure.
The results of the comparison are shown in Table 2. The
results of the comparison are shown in Table 2. The results
of the comparison are shown in Table 2. The results of the
comparison are shown in Table 2. The results of the comparison
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RESULTS

Table I

Internal Pressure Applied to Cylindrical Specimen

Run No.	E_a	E_c	$\frac{E_{min}}{E_{max}}$	E	D	ΔD	t	T_d	#stress-coat
17	206	835	.247	900	65	78	225	66.0	1204
18	197	780	.252	953	173	22.2	120	70.5	1204
19	130	443	.293	490	47	10.6	40	73.5	1206
20	203	830	.245	852	22	2.7	50	71.5	1205
21	200	894	.224	984	90	10.1	60	71.0	1205
Average value:			.252			10.6			

Table II

Axial Tensile Load Applied to Cylindrical Specimen

Run No.	E_a	E_c	$\frac{E_{min}}{E_{max}}$	E	D	ΔD	t	T_d	#stress-coat
23	638	-195	-.325	450	-187	-29.2	70	70.5	1207
24	652	-175	-.268	595	-57	-8.8	65	76.0	1208
27	642	-182	-.284	580	-62	-9.6	55	74.0	1207
Average value:			-.293			-15.9			

Table III

Axial Tensile Load Applied to Cylindrical Specimen
(Stresscoat on Specimen was Cracked)

Run No.	E_a	E_c	$\frac{E_{min}}{E_{max}}$	E	D	ΔD	t	T_d	#stress-Coat
25	568	-179	-.315	560	-8	-1.4	35	76.5	1208
26	675	-125	-.284	600	-75	-11.1	50	75.5	1208
Average value:			-.300			-6.2			

Initial pressure applied to cylindrical specimen

Specimen	1	2	3	4	5	6	7	8	9	10
1000	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1001	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1002	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1003	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1004	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1005	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1006	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1007	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1008	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1009	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1010	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0

Initial pressure applied to cylindrical specimen

Specimen	1	2	3	4	5	6	7	8	9	10
1000	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1001	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1002	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1003	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1004	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1005	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1006	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1007	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1008	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1009	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1010	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0

Initial pressure applied to cylindrical specimen
(Specimen on specimen was tested)

Specimen	1	2	3	4	5	6	7	8	9	10
1000	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1001	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1002	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1003	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1004	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1005	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1006	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1007	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1008	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1009	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1010	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0

Table IV

Internal Pressure Applied To Cylindrical Specimen
After Crack Pattern Had Been Formed By Tensile Load.

Run No.	E _a	E _c	$\frac{E_{min}}{E_{max}}$	E	D	%D	t	T _d	#Stress- coat
23a	134	592	.227	510	-82	-13.8	25	70.5	1207
24a	138	606	.228	590	-16	- 2.6	25	76.0	1208
27a	170	637	.267	545	-92	-14.4	35	74.0	1207
Average value:			.241			-10.2			

Table V

Internal Pressure Applied To Cylindrical Specimen
After Crack Pattern Had Been Formed By Tensile Load.
(Stresscoat On Specimen Was Crazed)

Run No.	E _a	E _c	$\frac{E_{min}}{E_{max}}$	E	D	%D	t	T _d	#Stress- coat
25a	140	512	.273	560	48	9.4	28	76.5	1208
26a	131	633	.207	608	-25	-4.0	35	75.5	1208
Average value:			.240			2.7			

Table VI

Investigation Of Crazing And Its Effect On The
Sensitivity Of Stresscoat As Applied To The
Calibration Bars.

Bar No.	Condition of Coat	Sensitivity 10 ⁻⁶ in/in.	Time Sec.	Temp. Fah.
1	clear	680	30	72.5
2	clear	620	30	72.5
3	clear	630	30	72.5
4	crazed	780	30	72.5
5	crazed	820	30	72.5
6	crazed	850	30	72.5
7	clear	700	30	72.5
8	clear	630	1	72.5
9	clear	620	1	72.5
10	clear	600	1	72.5

11-1507

...the fact that the ...

[illegible]

Y. G. Zlatos

1. Introduction to the subject of the course.
2. The course is designed to provide a comprehensive overview of the subject.
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DATE	TIME	WIND	SEA	TEMP	WIND	SEA	TEMP	WIND	SEA	TEMP
1001	7.27	50	4.0	84	000	775.	512	641	220	220
1002	7.27	25	0.0	25	000	707.	333	111	111	220
			7.0			040.				

Table 1

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Table VII

Summary of Biaxial Stress Conditions

$\frac{E_{min}}{E_{max}}$	$\frac{E_{min}/E_{max}}{e/E}$	S_{min}/E_{max}	$\%D$	$\%D_s$	Run
-1.0	3.39	-1.0	-24.4*	- 1.9	Torsion
-0.295	1.00	0.0	-15.9	-15.9	Tension
0.25	-0.849	0.5	10.6	- 6.1	Cylinder
1.0	-3.39	1.0	29.0*	- 9.9	Sphere

$$e/E = -.295/1 = -.295$$

* From Olsen's (11) data.

Table III

Summary of Physical Properties

Property	Unit	Value	Unit	Value	Unit	Value
Boiling Point	°C	101.0	°C	101.0	°C	101.0
Melting Point	°C	0.0	°C	0.0	°C	0.0
Density	g/cm ³	0.80	g/cm ³	0.80	g/cm ³	0.80
Viscosity	cp	0.1	cp	0.1	cp	0.1
Refractive Index	n _D ²⁰	1.33	n _D ²⁰	1.33	n _D ²⁰	1.33

Notes: 1. All values are at 20°C unless otherwise specified.

Source: Data from various sources.

Additional information regarding the properties and uses of the substance.

References: 1. Handbook of Chemistry and Physics, 55th Edition.

Further details and experimental data supporting the reported values.

RESULTS

- (1) When perpendicular strains are in the ratio of 4 to 1, about 10% less strain is required to produce a crack pattern on the specimen than was indicated by the calibration bars. (See Table I)
- (2) When perpendicular strains are in the ratio of 3.4 to -1, about 16% more strain was required to produce a crack pattern on the specimen than was indicated by the calibration bars. (See Table II)
- (3) The presence of crazing in the Stresscoat prior to straining the coat to failure has a definite effect other than that of making the crack pattern difficult to observe.
 - a. Tests with several calibration bars indicate that the presence of crazing decreases the sensitivity of the coat about 25%. (See Table VI)
 - b. Actual experiments with the specimen indicate that crazing does decrease the sensitivity, however, too few experiments have been conducted to give an approximate percentage decrease in sensitivity.
(See Table III and Table V)
- (4) The presence of strain cracks in one direction prior to straining the coat to failure in a perpendicular direction has a definite effect on the sensitivity of the Stresscoat.
 - a. When perpendicular strains are in a ratio of 4 to 1 and straining to failure has been previously obtained

- (1) When perpendicular strains are in the ratio of 4 to 1, about 10% less strain is required to produce a given category on the confusion than was indicated by the calibration data. (See Table I)
- (2) When perpendicular strains are in the ratio of 3.4 to 1, about 10% more strain was required to produce a given pattern on the confusion than was indicated by the calibration data. (See Table II)
- (3) The presence of strain in the testroom prior to training for the test to failure was a definite effect on the time of failure. The error category difficulty is observed. A test with repeated calibration data indicates that the presence of strain decreases the sensitivity of the test about 50%. (See Table VI)
- (4) Actual experiments with the confusion indicate that strain does decrease the sensitivity. However, for few experiments have been conducted to give an approximate percentage decrease in sensitivity. (See Table III and Table V)
- (5) The presence of strain causes in the confusion prior to training the test to failure in a perpendicular direction has a definite effect on the sensitivity of the testroom. A test perpendicular strain is in a ratio of 4 to 1 and training to failure has been previously obtained.

(4a) cont'.

in the minor direction, it has been found that about 10% more strain is required to produce a crack pattern on the specimen than was indicated by the calibration bars. (See Table IV)

- b. Experiments, conducted with a 15 inch square piece of celluloid loaded as a cantilever beam to a certain deflection in one direction and then to the same deflection in the same length of time in a direction perpendicular to the first test, indicated that a crack pattern in one direction had little if any effect on the formation of a crack pattern at right angles to the original pattern. Of four tests made in this manner every one indicated identical sensitivity in either direction.

in the minor direction, it has been found that about 10% more again is required to produce a first pattern on the specimen than was indicated

by the calibration curve. (See Table IV)

4. Experiments, conducted with a 15 inch square piece

of celluloid found as a calibrator gave to a

certain deflection in one direction and also to

the same deflection in the same length of time in

a direction perpendicular to the first test. In-

dicated that a second pattern in one direction was

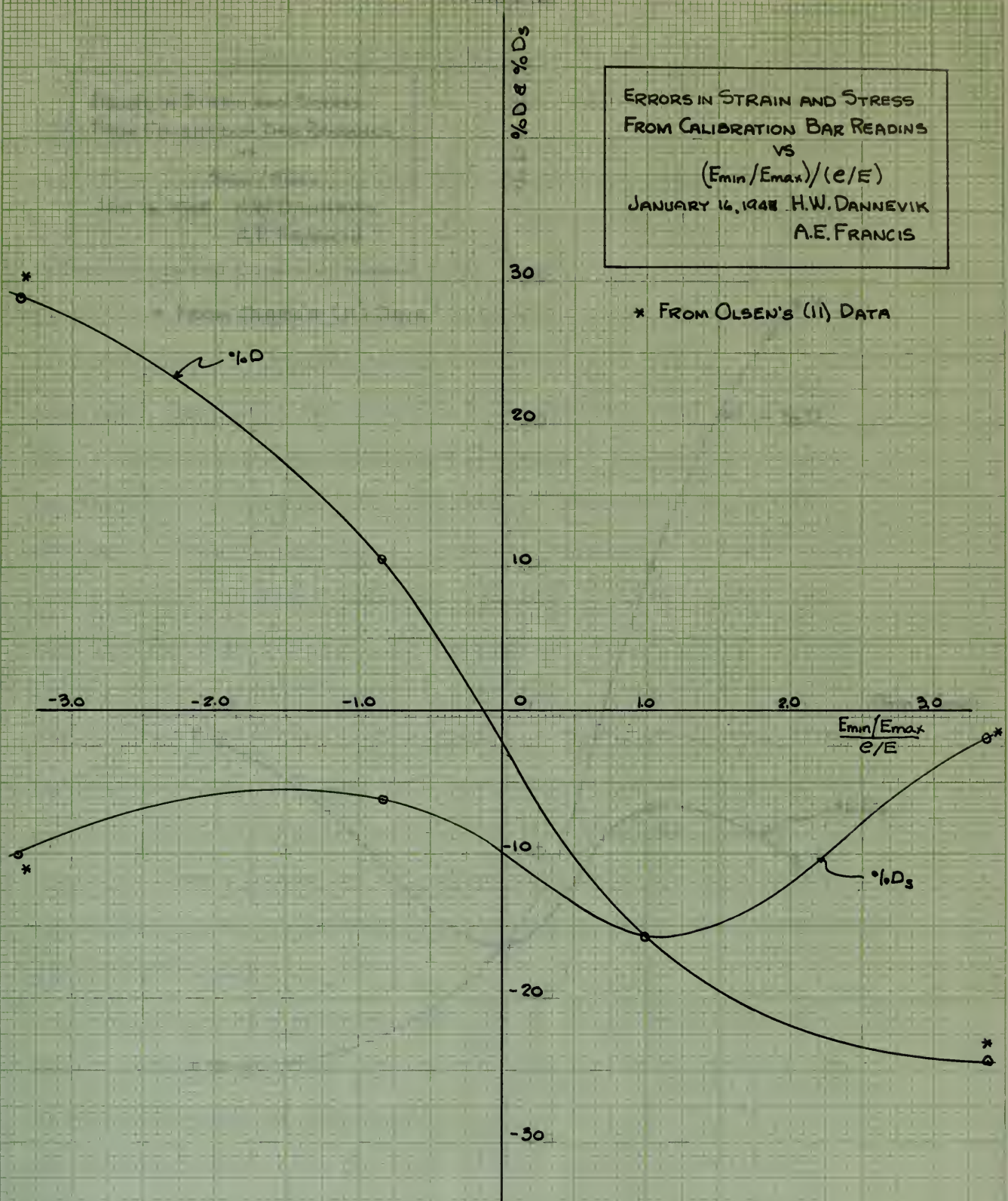
little if any effect on the formation of a second

pattern at right angles to the original pattern.

Of four tests made in this manner every one in-

dicated identical results in which direction

FIGURE I



Based on Data and Stems
 from Classroom and Review
 at
 June 1968
 Jan. 12, 1968 H.W. DAWSON
 A.E. FRANCIS

* From Ocean (1) Data



DISCUSSION OF RESULTS

General

Conclusions concerning the overall trends of the behavior of Stresscoat are the only ones which can be drawn from the results which have been presented. The lack of facilities for controlling atmospheric conditions rendered it impossible to obtain even two identical runs. The temperature, humidity and grade of Stresscoat used were continuously varying throughout all runs. Therefore, it was impossible to compare the results of runs except for discerning a general picture. Results of specific comparison value can be obtained only by varying a single condition influencing the behavior of Stresscoat while other influencing agents are maintained constant. Desirable results may be obtained either by making all tests in a room where the temperature and humidity are controlled or by running such a large number of tests that the required number of identical runs occur by coincidence. Lack of facilities prevented using the former method and lack of time prevented using the latter.

Although Stresscoat used in the field by an experienced operator may in some cases give accuracy within the limits required by engineering practice, the desirability of spending much time on investigation of its behavior relative to the various elastic theories is questionable unless more adequate facilities for experimentation are made available.

DISCUSSION OF RESULTS

General

Conclusions concerning the overall trends of the behavior of the system are the only ones which can be drawn from the results which have been presented. The lack of facilities for controlling atmospheric conditions rendered it impossible to obtain even two identical runs. The temperature, humidity and rate of air flow were continuously varying throughout all runs. Therefore, it was impossible to compare the results of runs except for determining a general picture. Results of specific comparisons can be obtained only by varying a single condition influencing the behavior of the system while other influencing agents are maintained constant. Reliable results may be obtained either by making all tests in a room where the temperature and humidity are controlled or by running such a large number of tests that the required number of identical runs occur by coincidence. Lack of facilities prevented using the former method and lack of time prevented using the latter.

Although the system used in this field by an experienced operator may in some cases give satisfactory results required by engineering practice, the reliability of operation such as in investigation of the behavior relative to the various elastic theories is questionable unless more adequate facilities for experimentation are made available.

The lack of temperature control also caused difficulty in maintaining equality of temperature between the specimen and the calibration bars, if the room temperature changed during the test. The difference in mass made the bars change in temperature much more quickly than the specimen did. This situation required artificial heating and cooling and often delayed runs annoyingly. The coatings, especially the more sensitive ones, were very susceptible to even small changes in temperature. A drop of two degrees in temperature may change the strain indicated by the lacquer of the order of one hundred micro inches.

No attempt was made to correlate stress with strain for any one run. The length of the specimen tended to reduce any deviation from pure axial loading during the tensile runs, but the slight disagreement between diametrically opposite strain gauges indicated some angularity of loading or local discontinuity of wall thickness. A slight discrepancy in strain gauge readings was also present during pressure runs. This disagreement was probably due to the bending of the specimen in the cradle, as the cracks in the coating appeared first on the bottom of the specimen, where the wall was subjected to tensile bending stress in addition to the stress from internal pressure. These conditions and some variance in the position of the specimen during the successive tests account for the occurrence of different strains in one direction when the strains in the perpendicular

The lack of temperature control also caused difficulty in maintaining equality of temperature between the sections and the calibration bars, at the two temperatures engaged during the test. The difference in heat made the bars expand in length much more quickly than the specimen did. This situation required artificial heating and cooling and often delayed runs considerably. The sections, especially the more sensitive ones, were very susceptible to even small changes in temperature. A drop of two degrees in temperature may change the strain indicated by the indicator of the order of one hundred micro inches.

No attempt was made to correlate stress with strain for any one run. The length of the specimen tested is so close to the distance from zero axial loading during the test runs, and the slight displacement between themselves opposite strain caused indicated some uncertainty in loading or local discontinuity of wall thickness. A slight difference in strain gauge location was also present during pressure runs. This displacement was probably due to the bending of the specimen in the grips, as the stress in the section appeared first on the bottom of the specimen, where the wall was subjected to tensile bending stress in addition to the stress from internal pressure. These conditions were verified in the location of the specimen during the successive tests because for the occurrence of different strains in one direction when the strain in the perpendicular

direction were equal. Consequently, strains, computed from the loading and specimen dimensions, erred from actual strains observed in the specimen by as much as ten percent. The magnitude of strain was obtained independently by the strain gauges. The values of axial load and internal pressure were used merely as an aid in applying the load uniformly.

Two-Dimensional Strain

The results obtained, combined with information determined by Olsen (11), give a rough overall picture of how the magnitude of the deviation of the calibration bar strain from the actual strain varies as the ratio of the two-dimensional strain varies from positive to negative unity. The internal pressure tests of this report $E_{\min}/E_{\max} = .25$ and the Olsen (11) hollow sphere test $E_{\min}/E_{\max} = 1.0$ indicated that as the ratio of E_{\min}/E_{\max} increases in a positive direction the amount of strain necessary to cause failure in the coating on the specimen becomes progressively less than that indicated by the calibration bars. Olsen's (11) pure torsion test $E_{\min}/E_{\max} = -1.0$ indicates that as the ratio of E_{\min}/E_{\max} approaches negative unity the strain necessary to cause failure in the coating on the specimen becomes progressively greater than the strain indicated by the calibration bar.

A positive theoretical explanation for the behavior of Strescoat described above was not attained. However, a possible explanation has been developed, but it depends on the following two assumptions for validity:

direction were equal. Consequently, strains, computed from the loading and specimen dimensions, error from actual strains observed in the specimen by as much as ten percent. The magnitude of strain was obtained independently of the strain gauge, the values of axial load and internal pressure were used merely as aid in analyzing the data uniformly.

Two-Dimensional Strain

The results obtained, compared with information derived by Class (II), give a rough overall picture of how the magnitude of the deviation of the calibration bar strain from the actual strain varies as the ratio of the two-dimensional strain varies from positive to negative unity. The internal pressure ratio of this report $\frac{P_{int}}{P_{ext}} = 0.5$ and the Class (II) hollow sphere test $\frac{P_{int}}{P_{ext}} = 1.0$ indicated that as the ratio of $\frac{P_{int}}{P_{ext}}$ increases in a positive direction the amount of strain necessary to cause failure in the wall on the specimen becomes progressively less than that indicated by the calibration bar. Class (II) test results test $\frac{P_{int}}{P_{ext}} = -1.0$ indicates that as the ratio of $\frac{P_{int}}{P_{ext}}$ approaches negative unity the strain necessary to cause failure in the wall on the specimen becomes progressively greater than the strain indicated by the calibration bar. A qualitative theoretical examination for the behavior of stresses described above was not obtained. However, a qualitative examination has been devised, not in general on the following two assumptions for validity:

(1) The stress in the coating is due to the strain in the base material and has no direct connection with the load on the specimen.

(2) Stresscoat fails in tension according to the Maximum Stress Theory.

When E_{min}/E_{max} is positive the Poisson effect of E_{min} tends to shorten the coating in the E_{max} direction. Each point in the coating is restrained by the surrounding lacquer so a tensile stress is induced in the E_{max} direction. Therefore, less direct tension is required to produce failure than if the tension induced due to E_{min} did not exist and the coating fails at a strain lower than that indicated by the calibration bar. When E_{min}/E_{max} is negative the Poisson effect of E_{min} tends to lengthen the coating in the E_{max} direction and a compression stress is induced in the lacquer in the E_{max} direction. For failure to occur in the coat, an amount of tension sufficient to overcome the induced compression is necessary in addition to the normal direct tension required for coat failure if the induced compression were not present. Consequently, the coat fails at a higher value of strain than indicated by the calibration bar. Both Olsen (11) and Durelli (14) experienced difficulty in producing failure in the coating, due to Poisson's effect only, in a direction perpendicular to a compression load. Such behavior of the lacquer conforms to the above theory.

Calibration

According to theory an element on the surface of a

(1) The slope in the positive is due to the strain in the same material and has no direct connection with the load on the specimen.

(2) The maximum strain in tension according to the maximum strain theory.

When ϵ_{max} is positive the maximum strain of strain tends to occur in the positive direction in the ϵ_{max} direction. When ϵ_{max} is negative the maximum strain tends to occur in the negative direction in the ϵ_{max} direction. In the case of a tensile stress is induced in the ϵ_{max} direction. There is a direct relation is reported to stress strain curve. The relation induced due to strain ϵ_{max} and the strain ϵ_{min} at a strain level that induced by the strain ϵ_{max} is negative and positive strain of strain in tension the strain in the ϵ_{max} direction and a compression strain is induced in the ϵ_{min} direction. The failure to occur in the case, an amount of tension sufficient to overcome the induced compression is necessary in addition to the normal direct tension required. The total failure if the induced compression were not present. Consequently, the total failure is a direct value of strain. It is indicated by the definition only. With stress (1) and (2) respectively in the ϵ_{max} direction. In the case, the relation's strain ϵ_{max} in a direction perpendicular to a compression force. Such relation to the failure occurs in the same theory.

Conclusion

According to theory an element on the surface of a

specimen loaded with axial tension only and an element on the top of a loaded cantilever beam are both subjected to the same pattern of two-dimensional strain. In the tension runs the ratio $\epsilon_{\min}/\epsilon_{\max}$ was equal to Poisson's ratio as expected; therefore, the disagreement between the actual strain causing failure and the strain indicated by the calibration bar was puzzling. The actual strain required to cause failure of the coating on the specimen was about 15% greater than that indicated by the calibration bar.

A check was made to insure that the calibration bar conformed to beam theory and Poisson's effect, and the results were positive. Further thought has made apparent a possible explanation for the disagreement described above. The thickness of the coat on the calibration bar is an appreciable fraction of the distance from the neutral axis to the outer surface of the bar. Consequently, the strain at the outer surface of the coating is greater than the actual strain on the bar surface underneath. Since the calibration frame is graduated in strain on the bar surface and the cracks initiate on the outer surface of the coat, the strain initiating the cracks is greater than that indicated by the calibration bar. When a specimen is under axial load the strain throughout the coating is the same as that on the surface of the specimen. The assumption that the strain in the outer surface of the bar coating and the strain in the tensile specimen were approximately the same accounts for the discrepancies observed. In contrast to the case of the calibration bar, during tensile runs the cracks were observed

specimen loaded with axial tension only and an element on the top of a loaded cantilever beam are both subjected to the same pattern of two-dimensional strain. In the tension test the ratio $\epsilon_{\text{axial}}/\epsilon_{\text{transverse}}$ was equal to Poisson's ratio as expected; therefore, the disagreement between the actual strain causing failure and the strain indicated by the calibration bar was peculiar. The actual strain appeared to agree fairly well of the coating on the specimen was about 15% greater than that indicated by the calibration bar.

A check was made to insure that the calibration bar conformed to beam theory and Poisson's effect, and the results were positive. Further thought was made as to a possible explanation for the disagreement reported above. The thickness of the coat on the calibration bar is an average fraction of the distance from the neutral axis to the outer surface of the bar. Consequently, the strain at the outer surface of the coating is greater than the actual strain on the bar surface underneath. Since the calibration frame is grounded in strain on the bar surface and the cracks initiate on the outer surface of the coat, the strain indicated along the cracks is greater than that indicated by the calibration bar. When a specimen is under axial load the strain throughout the coating is the same as that on the surface of the specimen. The assumption that the strain in the outer surface of the bar coating and the strain in the tensile specimen are approximately the same accounts for the discrepancies observed. In contrast to the case of the calibration bar, during tensile tests the cracks were observed

to originate on the surface of the base material and then spread outward through the coat.

Olsen's tensile investigation strengthens the theory presented above. The deviations he obtained compare favorably in magnitude and sign with those observed in this experiment. He commented on the inaccuracy of calibration but did not attach any significance to the fact that in each of his runs the calibration bar indicated strains less than those actually present.

The experience of Olsen and the authors suggest that there is an inherent error in strains indicated by the calibration bar except where the specimen is loaded in a condition of bending similar to that in the bar. This error is independent of that due to a particular condition of two-dimensional strain in the specimen.

Curves

In figures 1 and 2 the errors in strain and stress encountered when using the calibration bar are plotted as functions of S_{min}/S_{max} and $\frac{E_{min}}{E_{max}}$. During the tensile run the two-dimensional strain systems are the same in the specimen and the bar and the only error is the inherent error due to coat thickness which is always present when using the calibration bar. As far as stress is concerned this error, occurring alone for the condition of uniaxial stress, is the maximum error ever present. Evidently the error brought in due to the difference in the two-dimensional

to originate on the surface of the outer material and then spread outward through the coal.

Given a certain impregnation of the coal by the gas, the variation in the rate of diffusion is determined by the rate of diffusion of the gas in the coal. The rate of diffusion is determined by the rate of diffusion of the gas in the coal. The rate of diffusion is determined by the rate of diffusion of the gas in the coal. The rate of diffusion is determined by the rate of diffusion of the gas in the coal.

The existence of a gas in the coal is determined by the rate of diffusion of the gas in the coal. The rate of diffusion is determined by the rate of diffusion of the gas in the coal. The rate of diffusion is determined by the rate of diffusion of the gas in the coal. The rate of diffusion is determined by the rate of diffusion of the gas in the coal.

THEORY

In Figure 1 and 2 the error in the rate of diffusion is shown. The error in the rate of diffusion is shown. The error in the rate of diffusion is shown. The error in the rate of diffusion is shown. The error in the rate of diffusion is shown. The error in the rate of diffusion is shown. The error in the rate of diffusion is shown. The error in the rate of diffusion is shown. The error in the rate of diffusion is shown. The error in the rate of diffusion is shown.

strain system in the specimen and the bar and the inherent error tend to be compensating and reduce the total error in stress determination. When strain is the important consideration it is noted that the maximum error occurs at the extremities of the possible $\frac{E_{\min}/E_{\max}}{e/E}$ range. For strain determinations the point where one error completely compensates for the other error occurs where S_{\min}/S_{\max} has a value of about .25. The seriousness of these errors depends on the experimental error probable for the conditions of the test and the accuracy required.

Effect of Existing Cracks on Failure in Another Direction

When pressure runs were made after a tensile crack pattern had been previously obtained the calibration bar indicated less strain than that actually required to cause failure on the specimen. This occurrence, which is just opposite to that observed for initial pressure runs, was not satisfactorily understood. The circumferential closely spaced cracks already present eliminate the axial restraint normally present in an intact coating. This condition combined with the possibility of a creep effect (the technique claimed to eliminate creep by the manufacturer was always used) are the only apparent factors which may contribute to the peculiar behavior of the coating.

An attempt to gain further insight into this problem was made by experimenting with the flat celluloid plate. The results, indicating that cracks in one direction do not

obtain a value in the specimen and the bar and the important
 error, tend to be exaggerated and reduce the total error
 in stress determination. When stress is the important
 consideration it is noted that the relative error occurs at
 the extremities of the possible $\frac{\sigma_{max}}{\sigma_{min}}$ range. For strain
 determination the point where the error is relatively con-
 siderable for the error occurs where $\frac{\sigma_{max}}{\sigma_{min}}$ has a
 value of about .35. The seriousness of these errors depends
 on the experimental error probable for the conditions of
 the test and the accuracy required.

Effect of Elastic Strain on Strain in Another Direction

When stresses were made after a tensile stress
 pattern had been previously obtained the deformation was in-
 creased less strain than was normally required to cause
 failure on the specimen. This occurrence, which is well ob-
 served to that observed for initial pressure tests, was not
 satisfactorily understood. The experimental results clearly
 showed stress already present eliminated the usual resistance
 normally present in an elastic material. This condition com-
 bined with the possibility of a stress effect (the principle
 applied to airplane stress by the manufacturer was always
 used) and the only possible factor which may contribute to
 the peculiar behavior of the material.

An attempt to gain further insight into this problem
 was made by experimenting with the first elastic plate.
 The results, indicating that strains in one direction do not

influence cracking in the other perpendicular direction, did not increase the understanding of the situation. However, cracks on the edges of the crack patterns on the plate were farther apart, shorter and less well developed than the cracks which extended over the whole specimen.

Crazing

The runs made specifically to investigate the effect of crazing and those pressure and tensile runs where unintentional crazing occurred prior to the run, both indicated that the presence of crazing substantially decreases the sensitivity of the coating as well as making the initial cracks difficult to see. (As the sensitivity of the coating increases it fails at a lower value of strain). The error induced probably varies directly with the intensity of crazing. The more sensitive coats were more susceptible to crazing. The occurrence of crazing depended on the minimum temperature experienced prior to testing and also the rate of fall of the temperature. Even small changes in temperature caused crazing if the change was swift enough. Decreases in temperature caused stresses in the coating due to different thermal coefficients of expansion in the Stresscoat and the material underneath, which are finally relieved by crazing of the coating. After crazing has occurred much of the restraint in the coating at a local point due to the presence of the surrounding coating has been eliminated. When crazing occurred on bars which already contained a crack

influence exerted in the case of the different division, did not increase the understanding of the situation. However, even on the basis of the data obtained in the plate were further work, shorter and less well developed than the others which extended over the whole specimen.

Crazing

The work made specifically to investigate the effects of crazing and those pressure and tensile work were intentional crazing occurred prior to the run, both indicated that the presence of crazing substantially decreases the sensitivity of the coating as well as within the initial cracks difficult to see. (As the sensitivity of the coating increases it falls at a lower value of strain). The work induced probably varied directly with the intensity of strain. The more sensitive coats were more susceptible to crazing. The occurrence of crazing depended on the minimum temperature indicated prior to testing and also the rate of fall of the temperature. Even small changes in temperature caused crazing if the change was sufficiently great. Decreases in temperature caused crazing in the coating due to different thermal coefficients of expansion in the stress-coat and the material substrate, which are finally relieved by crazing of the coating. After crazing had occurred when of the craze in the coating at a local point due to the presence of the surrounding craze has been eliminated. When crazing occurred on bars which already contained a crack

pattern intense crazing occurred only on the uncracked portion and extended only from crack to crack. It is of interest to note that crazing decreased the sensitivity of a coat about 25% while the strain which produced failure in the pressure runs following a tensile run was 25% greater than the strain producing failure in an initial pressure run. Temperature change craze should not be confused with drying craze which usually does not present a problem.

Accuracy

The effect of creep is pronounced and should not be underestimated. A slight deviation was present between results obtained by loading the calibration bar in the same time as the specimen, and by using the creep correction chart supplied by the manufacturer and loading the bar in one second. However, this deviation was inconsistent in sign and probably was due to normal experimental error.

Most of the published material concerning the use of Stresscoat, except the manufacturer's detailed instructions, underestimate the difficulties which will be encountered in using Stresscoat when atmospheric conditions are not controllable.

A consideration of the accuracy with which a calibration bar may be read indicates that the maximum error likely is less than 10%. Olsen (11) found the same accuracy possible in reading calibration bars.

system infers strain occurred only on the unstrained
 portion and extended only from crack to crack. It is of
 interest to note that strain measured the sensitivity of
 a coil about 50% while the strain which produced failure in
 the specimens was following a tensile test the 50% strain
 when the strain producing failure in an initial specimen
 run. Temperature change may should not be confused with
 drying stress which usually does not present a problem.

Summary

The effect of stress is pronounced and should not be
 underestimated. A slight deviation was present between the
 value obtained by loading the specimen and in the case
 the stress recovery, and by using the stress correction
 factor supplied by the manufacturer and for the fiber in
 one second. However, this deviation was insignificant in
 view and probably was due to some experimental error.
 Some of the published material concerning the use of
 stress, except the manufacturer's detailed instructions,
 underestimate the difficulties which will be encountered in
 using stress when atmospheric conditions are not carefully
 noted.

A consideration of the accuracy with which a strain-
 ion bar may be read indicates that the maximum error likely
 is less than 10%. Given (1) Young's modulus accuracy 50%
 and (2) reading calibration error.

Future Work

It is desirable that the behavior of Stresscoat be investigated for other conditions of biaxial stress in addition to those covered by this report. This additional information would confirm or disprove the shape of the curves of Figures 1 and 2. An attempt to obtain failure of the coat at other ratios of E_{\min}/E_{\max} was made but the uniform application of internal pressure and axial load simultaneously, which is required due to the creep characteristics of the coating, was impossible with the experimental set-up and the personnel available. The production of apparatus to accomplish this should not be difficult. The use of a small specimen is recommended.

The Poisson's ratio and the modulus of elasticity of Stresscoat itself are important characteristics, the determination of which will allow further insight into the behavior of Stresscoat. With controlled atmospheric conditions it will be possible to limit a series of runs to one grade of Stresscoat. If the Poisson's ratio and the modulus of elasticity for a particular grade of Stresscoat are known, together with the principal strains existing at failure over the possible range of biaxial stress conditions, the actual stress in the coating at failure can be determined. The values of such stresses can be employed to ascertain the theory of failure which Stresscoat follows.

It is desirable that the behavior of the system be investigated for other conditions of initial stress in addition to those covered by this report. The additional information would consist of determining the effect of the waves of stress I and II. An attempt to obtain failure of the cord at other ratios of $\frac{v}{c}$ may be made but the uniform excitation of internal stresses and initial load conditions must be required due to the even excitation of the cord. It was impossible with the experimental set-up and the response available. The production of a constant to excitation rate should not be difficult. The use of a small specimen is recommended.

The Poisson's ratio and the modulus of elasticity of the material itself are important characteristics, and the determination of which will allow further insight into the behavior of the system. With controlled specimens of cord it will be possible to find a series of tests to the grade of the material. If the Poisson's ratio and the modulus of elasticity for a particular grade of material are known, together with the principal stresses existing at failure, then the possible range of initial stress conditions, and the effect of stress in the cord at failure can be determined. The values of such stresses can be employed to ascertain the history of failure which preceded failure.

Summation

The discussions presented have been based on averages of several runs. Although the spread of results for each series of similar runs was quite wide, all the results for each series of runs were of the same sign. After considering the unfavorable conditions under which the investigations were made it is felt that the consistency of the results obtained, and the favorable comparison with Olsen's (11) work, have allowed the authors to present a reasonably accurate overall picture.

The discussion presented here is based on evidence of several types. Although the extent of results for each series of similar runs was quite wide, all the results for each series of runs were of the same sign. After considering the unfavorable conditions under which the investigations were made it is felt that the consistency of the results obtained, and the favorable comparison with other (11) work, have allowed the authors to present a reasonably accurate overall picture.

The first series of experiments was conducted with a...
The second series of experiments was conducted with a...
The third series of experiments was conducted with a...
The fourth series of experiments was conducted with a...
The fifth series of experiments was conducted with a...
The sixth series of experiments was conducted with a...
The seventh series of experiments was conducted with a...
The eighth series of experiments was conducted with a...
The ninth series of experiments was conducted with a...
The tenth series of experiments was conducted with a...
The eleventh series of experiments was conducted with a...
The twelfth series of experiments was conducted with a...
The thirteenth series of experiments was conducted with a...
The fourteenth series of experiments was conducted with a...
The fifteenth series of experiments was conducted with a...
The sixteenth series of experiments was conducted with a...
The seventeenth series of experiments was conducted with a...
The eighteenth series of experiments was conducted with a...
The nineteenth series of experiments was conducted with a...
The twentieth series of experiments was conducted with a...

CONCLUSIONS

1. If results of theoretical value are to be obtained from experimenting with Stresscoat the experiments must be conducted in a controlled atmosphere.
2. The presence of biaxial stresses in a specimen under investigation and the consequent difference between the two-dimensional strain systems in the specimen and the calibration bar cause the strain indicated by the calibration bar to err from that strain causing failure in the Stresscoat on the specimen. The magnitude and direction of this deviation varies, as the ratio of minimum to maximum strain in the specimen changes from the corresponding ratio in the calibration bar.
3. When the specimen under investigation is loaded in a different manner than the calibration bar the strain indicated by the calibration bar is in error.
4. For stress determinations the two errors above are compensating and the total error is a maximum when the inherent calibration bar error is the only one present.
5. For strain determinations the maximum positive and negative errors occur at the extremities of the $\frac{E_{min}/E_{max}}{e/E}$ and S_{min}/S_{max} ranges. Somewhere within the extremities there is a point of no error.
6. Crazeing affects the sensitivity of Stresscoat. The presence of previously obtained crack pattern affects the sensitivity of the coating to cracking in another direction.

CONCLUSIONS

1. If results of experimental values are to be obtained from experiments with specimens the size of which must be controlled in a controlled manner.
2. The presence of residual stresses in a specimen under investigation and the consequent differences between the two-dimensional strain systems in the specimen and the calibration bar cause the strain indicated by the calibration bar to be from four strain systems failure in the specimen. The magnitude and direction of this deviation varies, as the ratio of strain to maximum strain in the specimen changes from the corresponding ratio in the calibration bar.
3. When the specimen under investigation is loaded in a different manner than the calibration bar the strain indicated by the calibration bar is in error.
4. For stress determinations the two errors above are compensating and the total error is a maximum when the inherent calibration bar error is the only one present.
5. For strain determinations the maximum positive and negative errors occur at the extremes of the $\frac{\epsilon_{max}}{\epsilon_{min}}$ and $\frac{\epsilon_{min}}{\epsilon_{max}}$ ranges. Somewhere within the extremes there is a ratio of no error.
6. Given these the sensitivity of stress-strain curves of uniaxially loaded stress-strain curves the sensitivity of the system to strain is constant.

RECOMMENDATIONS

1. If further investigation in the field of strain indicating brittle lacquer is undertaken, facilities for experimenting under controlled atmospheric conditions should be supplied.
2. Further investigation of the behavior of Stresscoat when subjected to biaxial stress should be made under controlled atmospheric conditions and for more ratios of S_{min}/S_{max} .
3. The Poisson's ratio and modulus of elasticity and then the theory of failure of Stresscoat should be determined.
4. An investigation of the causes and affects of crazing on the behavior of Stresscoat should be made.

APPENDIX

THE HISTORY OF THE UNITED STATES

The history of the United States is a story of growth and change. From the first settlers to the present day, the nation has evolved through various stages of development. The early years were marked by exploration and settlement, followed by a period of rapid expansion and industrialization. The American Revolution and the subsequent years of the 18th and 19th centuries saw the nation's political and social structure take shape. The Civil War was a pivotal moment in the nation's history, leading to the abolition of slavery and the strengthening of the federal government. The 20th century brought further challenges, including the Great Depression, World War II, and the Cold War. The nation has continued to grow and change, facing new challenges and opportunities in the 21st century.

APPENDIX

The appendix contains a collection of documents and materials that provide additional context and information about the history of the United States. These include letters, speeches, and other historical records. The documents are arranged chronologically, allowing readers to see the progression of events and the development of the nation's history. The appendix is a valuable resource for anyone interested in the history of the United States, providing a wealth of information and insight into the nation's past.

APPENDIX A
DETAILS OF PROCEDURE

Description of Apparatus

Specimen

The body of the specimen was a drawn seamless tube. The outside diameter was $4\frac{1}{2}$ inches and the wall thickness was .140 inches. The material conformed with Navy Specification A-44-T-13, Cat. No. 1077, 44-T-5450-10. The composition was .25% carbon, .70% Manganese, .04% Phosphorous, and .04% Sulphur. The yield point was 35,000 psi and the ultimate strength was 60,000 psi. The length of the body was 30 inches.

The ends were machined from rough steel forgings. The inner extremities of the ends were machined to fit snugly into the tube for a distance of two inches. The outer extremities were turned down to two inches in diameter and then drilled and tapped with a $1\frac{1}{2}$ inch, 7 threads per inch tap. The end pieces were secured to the body by both fillet and plug welds.

Each end of the specimen was fitted with a 6,000 psi valve. One end was connected to the pump through a portable section of high pressure copper tubing by means of two heavy duty unions.

Strain Gauges and Strain Indicator

The SR-4 strain gauges were Bonded Resistance Wire type strain gauges manufactured by the Baldwin Southwork

Division, Baldwin Locomotive Works. The specific type gauge used was an A-3, 13/16 inch gauge length, 120 ohm, and with a gauge factor of 2.03. The strain readings were obtained by the use of an SR-4 Strain Gauge Indicator, also manufactured by Baldwin.

Testing Machine

The tensile loading machine that was used was a Riehle Tensile Testing Machine, No. 214, having a maximum load capacity of 100,000 lbs. It was located in the Material Test Laboratory, Massachusetts Institute of Technology.

Hydraulic Pump

The pump used was a 10,000 lb. capacity hydraulic pump, a type sometimes used as a jack.

Division, Baldwin Locomotive Works. The specific type
group used was an A-3, 17 1/2 inch gauge locomotive, 120 inch
and with a gauge factor of 2.03. The strain specimens
were obtained by the use of an A-3 strain gauge indicator,
also manufactured by Baldwin.

Testing Machine

The specific testing machine that was used was a
Hinds Testing Machine, No. 214, having a rated
maximum capacity of 100,000 lbs. It was located in the
material test laboratory, Massachusetts Institute of
Technology.

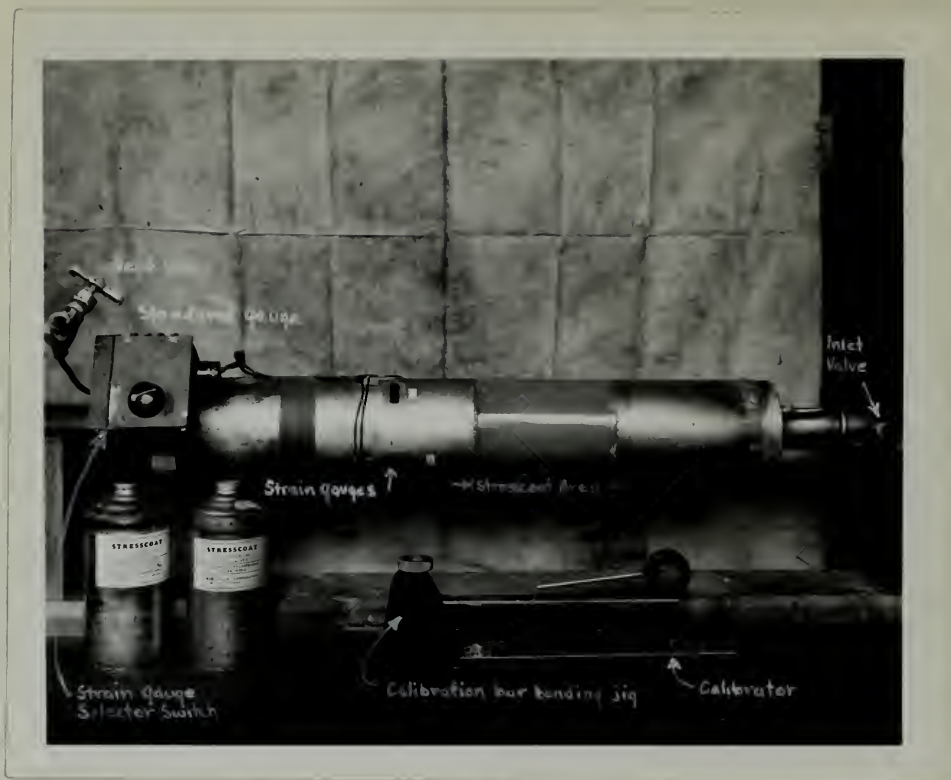
Hydraulic Press

The press used was a 10,000 lb. capacity hydraulic
press, a type sometimes used as a jack. The
specimen was held in the press by a fixture which was
designed to hold the specimen in the center of the
press and to apply the load uniformly to the specimen.

The specimen was held in the press by a fixture which was
designed to hold the specimen in the center of the
press and to apply the load uniformly to the specimen.
The specimen was held in the press by a fixture which was
designed to hold the specimen in the center of the
press and to apply the load uniformly to the specimen.

Specimen Preparation

The specimen was prepared by the use of a lathe and a
drill press. The specimen was first turned on a lathe
to the desired diameter and then drilled to the desired
length.



Experimental Specimen



Experimental Arrangement

APPENDIX B

SAMPLE CALCULATIONS

Correction for Lateral Sensitivity of SR-4 Strain Guage

The corrections for lateral sensitivity were made as outlined in reference (15). SR-4 strain guages are calibrated for uniaxial stress along the axis, on steel having a Poisson's ratio, ν , of .285. In any case involving two guages at right angles, if the conditions of strain under which the guages were calibrated are given, it is possible to find the true strains by the two simultaneous equations:

$$E_{\max} = \frac{(1 - \nu_0 K)(e_{\max} - K e_{\min})}{(1 - K^2)}$$

$$E_{\min} = \frac{(1 - \nu_0 K)(e_{\min} - K e_{\max})}{(1 - K^2)}$$

Where symbols have meanings shown by Table of Symbols.

Typical Pressure Run (No. 17) $t = 225$ seconds.

$$e_a = (230 + 220)/2 = 225 \quad e_c = (850 + 840)/2 = 845$$

$$E_a = \frac{[1 - (.285)(.021)][225 - (.021)(845)]}{[1 - (.021)^2]} = 206 = E_{\min}$$

$$E_c = \frac{[1 - (.285)(.021)][845 - (.021)(225)]}{[1 - .021^2]} = 835 = E_{\max}$$

$$E_a/E_c = E_{\min}/E_{\max} = 206/835 = .247$$

APPENDIX B BASIC CALCULATIONS

Correction for lateral sensitivity of 30-4 degree beam

The correction for lateral sensitivity was made as outlined in reference (1). 30-4 degree beam was utilized for uniaxial stress along the axis, on steel having a Young's ratio, ν , of .282. In any case involving two beams at equal angles, if the conditions of stress under which the gauges were calibrated are given, it is possible to find the true strains by the two simultaneous equations:

$$E_{max} = \frac{(1 - \nu K)(E_{max} - K E_{min})}{(1 - K^2)}$$

$$E_{min} = \frac{(1 - \nu K)(E_{min} - K E_{max})}{(1 - K^2)}$$

These symbols have meanings shown by Table of Symbols.

Typical Pressure Run (No. 17) $\epsilon = 232$ sec/cm.

$$E_c = (530 + 550) / 2 = 542 \quad \epsilon_c = (820 + 840) / 2 = 832$$

$$E_c = \frac{[1 - (.582)(.051)] [552 - (.051)(842)]}{[1 - (.051)^2]} = 506 = E_{min}$$

$$E_c = \frac{[1 - (.582)(.051)] [842 - (.051)(552)]}{[1 - (.051)^2]} = 832 = E_{max}$$

$$E_c / E_c = E_{min} / E_{max} = 506 / 832 = .611$$

APPENDIX B
SAMPLE CALCULATIONS

For Calibration bar loaded in 225 seconds.

$$E = (920 + 920 + 860) / 3 = 900$$

$$E - E_c = 900 - 835 = 65$$

$$\%D = (100)(65) / (835) = 7.7\%$$

For calibration bar loaded in 1 second and creep corrected.

$$E = (1000 + 960 + 1000) / 3 = 987$$

Typical Tensile Run (No. 23) t = 70 seconds

$$e_a = (655 + 620) / 2 = 638 \quad e_c = (-210 - 180) / 2 = -195$$

$$E_a = \frac{[1 - (.285)(.021)][638 - (.021)(-195)]}{[1 - (.021)^2]} = 637 = E_{max}$$

$$E_c = \frac{[1 - (.285)(.021)][-195 - (.021)(638)]}{[1 - (.021)^2]} = -207 = E_{min}$$

$$E_c / E_a = E_{min} / E_{max} = -207 / 637 = -.325$$

For calibration bar loaded in 70 seconds.

$$E = 450 \quad E - E_a = 450 - 637 = -187$$

$$\%D = (100)(-187) / (637) = -29.4\%$$

QUESTION

ANSWER

For calculation see below in the answer.

$$E = (450 + 450 + 800) / 3 = 900$$

$$E - E^* = 900 - 832 = 68$$

$$d.D = (100)(.02)(.832) = 1.14$$

For calculation see below in the answer.

$$E = (1000 + 450 + 1000) / 3 = 883$$

General formula for E^* and E_{max}

$$E^* = (450 + 450) / 2 = 450$$

$$E_{max} = \frac{[1 - (.05)] \cdot [1 - (.05)] \cdot [1 - (.05)] \cdot [1 - (.05)]}{[1 - (.05)]}$$

$$E_{min} = \frac{[1 - (.05)] \cdot [1 - (.05)] \cdot [1 - (.05)] \cdot [1 - (.05)]}{[1 - (.05)]}$$

$$E^* / E_{max} = E_{min} / E_{max} = .501 / .931 = .538$$

For calculation see below in the answer.

$$E = 450 \quad E - E^* = 450 - 450 = 0$$

$$d.D = (100)(.02)(.450) = 0.9$$

APPENDIX B
SAMPLE CALCULATIONS

For calibration bar loaded in 1 second and creep corrected.

$$E = (580 + 430 + 560)/3 = 523$$

Stress Calculations

For the calibration bar case.

$$S_{max} = \frac{E_m(E + \nu e)}{(1 - \nu^2)} \quad e = -.295E = -\nu E$$

$$S_{max} = \frac{E_m(E - \nu^2 E)}{1 - \nu^2} = \frac{E_m(1 - \nu^2)E}{1 - \nu^2} = E_m E$$

For the cylinder under internal pressure.

$$E_{min} = .25E_{max} \quad E_{max} = .905 E$$

$$\begin{aligned} S_{max} &= \frac{E_m(E_{max} + \nu E_{min})}{(1 - \nu^2)} = \frac{E_m[E_{max} + (.295)(.25)E_{max}]}{.913} \\ &= \frac{(1.0738)(E_m E_{max})}{.913} = \frac{(1.0738)(.905)E_m E}{.913} = 1.064 E_m E \end{aligned}$$

$$\% D_s = (100)(1 - 1.064)/(1.064) = -6.1\%$$

The calculations for the cases of pure torsion, axial load, and the sphere under internal pressure are similar to those above.

PROBLEM 1

PROBLEM 1

The following information is given for the project:

$$E = (280 + 430 + 250) / 3 = 320$$

Expected Value

For the expected value:

$$E_{max} = E_w(E + V_E) / (1 - V_E)$$

$$E = -252E = -V_E$$

$$E_{max} = E_w(E - V_E) / (1 - V_E) = E_w(1 - V_E)E = E_wE$$

For the expected value:

$$E_{min} = .52E_{max} \quad E_{max} = .902E$$

$$E_{max} = E_w(E_{max} + V_{E_{min}}) / (1 - V_E) = E_w[E_{max} + (.52)(.902)E_{max}] / .478$$

$$E_{max} = (1.0138)(E_w E_{max}) / .478 = (1.0138)(.902)E_w E_{max} = 1.044E_w E_{max}$$

$$1.044 = (1.0138)(.902) / (1 - 1.044) = -0.14$$

The following information is given for the project:

above

APPENDIX C
ORIGINAL DATA

2. REVISION

AND JOURNAL

Test #17	<u>Application</u>	<u>Test</u>
Date	5 Dec 1947	6 Dec 1947
Time	1300	1000
Wet Bulb	50.5° F	50° F
Dry Bulb	71° F	66° F
#Stresscoat Used	#1204	#1204
#Stresscoat Called For	#1202	#1201
Time of Loading Specimen		225 sec

Specimen Temp. at time of coat failure: 70.5° F

Internal Pressure psi gage	Axial Load Lbs.	<u>Strain Gage (micro inches)</u>			
		1	2	3	4
0	0	420	250	850	180
		#8 ref	#4	#5	#7
2100	0	650	1100	1070	1020
		#8	#4	#5	#7
0	0	455	250	840	175
		#8	#4	#5	#7

Calibration Bar No.	1	2	3	4	5	6
Strain, Micro Inches	780	750	920	920	780	860
Time of Loading Bar, Secs.	1	1	225	225	1	225
Bar Temperature, degrees F	70.5	70.5	70.5	70.5	70.5	70.5

Test No.	Time	Rate
1000	1000	1000
1000	1000	1000
1000	1000	1000
1000	1000	1000
1000	1000	1000
1000	1000	1000
1000	1000	1000
1000	1000	1000
1000	1000	1000
1000	1000	1000

Test No.	Time	Rate	Time of Loading	Time of Unloading
1000	1000	1000	1000	1000
1000	1000	1000	1000	1000
1000	1000	1000	1000	1000
1000	1000	1000	1000	1000
1000	1000	1000	1000	1000
1000	1000	1000	1000	1000
1000	1000	1000	1000	1000
1000	1000	1000	1000	1000
1000	1000	1000	1000	1000
1000	1000	1000	1000	1000

Test No.	Time	Rate	Time of Loading	Time of Unloading
1000	1000	1000	1000	1000
1000	1000	1000	1000	1000
1000	1000	1000	1000	1000
1000	1000	1000	1000	1000
1000	1000	1000	1000	1000
1000	1000	1000	1000	1000
1000	1000	1000	1000	1000
1000	1000	1000	1000	1000
1000	1000	1000	1000	1000
1000	1000	1000	1000	1000

<u>Test #18</u>	<u>Application</u>	<u>Test</u>
Date	6 Dec 1947	7 Dec 1947
Time	1100	1000
Wet Bulb	50° F	52° F
Dry Bulb	66° F	70.5° F
#Stresscoat Used	#1204	#1204
#Stresscoat Called For	#1201	
Time of Loading Specimen		120 sec

Specimen Temp. at time of coat failure: 69° F

Internal Pressure psi gage	Axial Load Lbs.	<u>Strain Gage (micro inches)</u>			
		1	2	3	4
0	0	505	415	1185	340
		#8 ref	#4	#5	#7
1925	0	750	1210	1370	1120
		#8	#4	#5	#7

Calibration Bar No.	1	2	3	4	5	6
Strain, Micro Inches	680	950	700	905	1010	800
Time of Loading Bar, Secs.	1	120	1	120	120	1
Bar Temperature, degrees F	69	69	69	69	69	69

Remarks:

It was necessary to cool bars and specimen to obtain sensitivity of practical value. A marked variation of sensitivity with a small temperature change in bars was noted. One bar spontaneously crazed at 64° F. This bar when bent gave an obviously inconsistent strain reading of 1200 micro inches/inch.

<u>Test #19</u>	<u>Application</u>	<u>Test</u>
Date	8 Dec 1947	9 Dec 1947
Time	1300	900
Wet Bulb	54° F	54° F
Dry Bulb	74° F	73.5° F
#Stresscoat Used	#1206	#1206
#Stresscoat Called For	#1204	
Time of Loading Specimen		40 sec.

Specimen Temp. at time of coat failure: 73.5° F

<u>Internal Pressure</u> <u>psi gage</u>	<u>Axial Load</u> <u>Lbs.</u>	<u>Strain Gage (micro inches)</u>			
		1	2	3	4
0	0	390	310	920	280
		#8 ref	#4	#5	#7
1200	0	530	785	-	700
		#8	#4	-	#7

Calibration Bar No.	1	2	3	4	5	6
Strain, Micro Inches	550	450	440	490	490	440
Time of Loading Bar, Secs.	1	1	1	40	40	1
Bar Temperature, degrees F	74.5	73.75	73.5	73.75	73.75	73.5

<u>Test #20</u>	<u>Application</u>	<u>Test</u>
Date	9 Dec 1947	10 Dec 1947
Time	1300	1300
Wet Bulb	54° F	53° F
Dry Bulb	74° F	71.5° F
#Stresscoat Used	#1205	#1205
#Stresscoat Called For	#1203	

Time of Loading Specimen 50 sec.

Specimen temp. at time of coat failure: 71.5° F

<u>Internal Pressure</u> <u>psi gage</u>	<u>Axial Load</u> <u>Lbs.</u>	<u>Strain Gage (micro inches)</u>			
		1	2	3	4
0	0	250	1190	620	1100
		#8 ref	#2	#5	#6
2050*	0	475	1060	840	1940
		#8	#4	#5	#6

<u>Calibration</u>										
<u>Bar No.</u>	1	2	3	4	5	6	7	8	9	10
<u>Strain,</u>										
<u>Micro Inches</u>	700	700	860	900	670	780	730	810	790	905
<u>Time of Load-</u>										
<u>ing Bar, Secs.</u>	1	1	1	50	1	50	1	50	1	50
<u>Bar Temperature</u>										
<u>degrees F</u>	71.5	71.5	71.5**	71.5	71.5**	71.5	71.5	71.5	71.5	71.5

Remarks:

* This run was made after the specimen had been loaded in tension to the design strength of the specimen, but no circumferential cracks in stresscoat were noted. The Stresscoat was allowed to recover for a time in excess of two times the time to load the specimen; before the internal pressure was applied.

** Bar number 3 was a thicker coat than the best specimen and Bar number 5 was an exceedingly thin coat.

Year 1967	Year 1968	Year 1969
Date	0 Jan 1967	10 Jan 1967
Time	1300	1300
Not valid	Yes	Yes
Not valid	Yes	Yes
Estimated time	(1200)	(1200)
Estimated time for	(1200)	(1200)
Time of loading machine	00 min	00 min

Year 1967	Year 1968	Year 1969
Date	0 Jan 1967	10 Jan 1967
Time	1300	1300
Not valid	Yes	Yes
Not valid	Yes	Yes
Estimated time	(1200)	(1200)
Estimated time for	(1200)	(1200)
Time of loading machine	00 min	00 min

Year 1967	Year 1968	Year 1969
Date	0 Jan 1967	10 Jan 1967
Time	1300	1300
Not valid	Yes	Yes
Not valid	Yes	Yes
Estimated time	(1200)	(1200)
Estimated time for	(1200)	(1200)
Time of loading machine	00 min	00 min

This was also done for the machine and was loaded
 in January to the machine and to the machine, but
 no experimental error in January was noted.
 The experiment was done in January for a time in
 error of the time and to the machine.
 Before the internal pressure was applied.
 The number 2 was a number 2 and the number 2
 and the number 2 was a number 2 and the number 2

<u>Test #21</u>	<u>Application</u>	<u>Test</u>
Date	10 Dec 1947	11 Dec 1947
Time	1600	1300
Wet Bulb	53° F	52° F
Dry Bulb	71.5° F	70.75° F
#Stresscoat Used	#1205	#1205
#Stresscoat Called For	#1202	

Time of Loading Specimen 60 sec

Temp. of specimen at time of coat failure: 70.75° F

<u>Internal Pressure</u> <u>psi gage</u>	<u>Axial Load</u> <u>Lbs.</u>	<u>Strain Gage (micro inches)</u>			
		1	2	3	4
0	0	240	180	590	80
		#8 ref	#4	#5	#7
2175*	0	440	1090	830	980
		#8	#4	#5	#7

Calibration Bar No.	1	2	3-A	3-B	4-A	4-B	5
Strain, Micro Inches	900	900	960	810	1010	800	800
Time of Loading Bar, Secs.	1	1	60	1	60	1	1
Bar Temperature, degrees F	70.75	70.75	71.5	71.5	71.5	71.5	71.5

Remarks:

- * This run was made after the specimen had been loaded in tension to the design strength of specimen but no cracks were noted in the Stresscoat. The Stresscoat was allowed to recover for a time in excess of two times the time allowed to load the specimen, before the internal pressure was applied.

Test No.	Location	Test No.
11-10-1947	10-10-1947	
1000	1000	
1000	1000	
10.75	11.5	
1000	1000	
	1000	
	1000	
	1000	

Test No.	Location	Test No.
11-10-1947	10-10-1947	
1000	1000	
1000	1000	
10.75	11.5	
1000	1000	
	1000	
	1000	
	1000	

Test No.	Location	Test No.
11-10-1947	10-10-1947	
1000	1000	
1000	1000	
10.75	11.5	
1000	1000	
	1000	
	1000	
	1000	

Test No.	Location	Test No.
11-10-1947	10-10-1947	
1000	1000	
1000	1000	
10.75	11.5	
1000	1000	
	1000	
	1000	
	1000	

Test No.	Location	Test No.
11-10-1947	10-10-1947	
1000	1000	
1000	1000	
10.75	11.5	
1000	1000	
	1000	
	1000	
	1000	

<u>Test #22</u>	<u>Application</u>	<u>Test</u>
Date	11 Dec 1947	12 Dec 1947
Time	1600	1300
Wet Bulb	52° F	53° F
Dry Bulb	70.5° F	71° F
#Stresscoat Used	#1206	#1206
#Stresscoat Called For	#1202	
Time of Loading Specimen		(A) 45 sec (B) 75 sec
Temp of Specimen at time of coat failure:	71.5° F	

<u>Internal Pressure</u> <u>psi gage</u>	<u>Axial Load</u> <u>Lbs.</u>	<u>Strain Gage (micro inches)</u>			
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
0	0	260	230	640	130
		#8 ref	#4	#5	#7
(A)* 1900	0	480	980	830	870
		#8	#4	#5	#7
(B) 1470	35000	935	660	1270	570
		#8	#4	#5	#7

Calibration Bar No.	3A	3B
Strain, Micro Inches	730	730
Time of Loading Bar, Secs.	1	75
Bar Temperature, degrees F	71.5	71.5

Remarks:

Longitudinal cracks (very apparent) appeared with $P_1 = 1900$ psig. and $P_a = 0$ in test A. Time of loading 45 sec. Circumferential cracks appeared with loading $P_1 = 1470$ psig. and $P_a = 35000$ lbs. as indicated. Time of loading 75 secs.

Both the bars and the specimen were badly crazed, however, the cracks from loading were readily apparent on the specimen, but were almost impossible to see on the bars.

* This run was made after the specimen had been loaded in tension with no cracks appearing in Stresscoat. It was allowed to recover.

Test No.	Location	Time	Wet Soil	Dry Soil	Observations
1000	1000-1001	1000	1000	1000	1000
1001	1001-1002	1001	1001	1001	1001
1002	1002-1003	1002	1002	1002	1002
1003	1003-1004	1003	1003	1003	1003
1004	1004-1005	1004	1004	1004	1004
1005	1005-1006	1005	1005	1005	1005
1006	1006-1007	1006	1006	1006	1006
1007	1007-1008	1007	1007	1007	1007
1008	1008-1009	1008	1008	1008	1008
1009	1009-1010	1009	1009	1009	1009
1010	1010-1011	1010	1010	1010	1010
1011	1011-1012	1011	1011	1011	1011
1012	1012-1013	1012	1012	1012	1012
1013	1013-1014	1013	1013	1013	1013
1014	1014-1015	1014	1014	1014	1014
1015	1015-1016	1015	1015	1015	1015
1016	1016-1017	1016	1016	1016	1016
1017	1017-1018	1017	1017	1017	1017
1018	1018-1019	1018	1018	1018	1018
1019	1019-1020	1019	1019	1019	1019
1020	1020-1021	1020	1020	1020	1020
1021	1021-1022	1021	1021	1021	1021
1022	1022-1023	1022	1022	1022	1022
1023	1023-1024	1023	1023	1023	1023
1024	1024-1025	1024	1024	1024	1024
1025	1025-1026	1025	1025	1025	1025
1026	1026-1027	1026	1026	1026	1026
1027	1027-1028	1027	1027	1027	1027
1028	1028-1029	1028	1028	1028	1028
1029	1029-1030	1029	1029	1029	1029
1030	1030-1031	1030	1030	1030	1030
1031	1031-1032	1031	1031	1031	1031
1032	1032-1033	1032	1032	1032	1032
1033	1033-1034	1033	1033	1033	1033
1034	1034-1035	1034	1034	1034	1034
1035	1035-1036	1035	1035	1035	1035
1036	1036-1037	1036	1036	1036	1036
1037	1037-1038	1037	1037	1037	1037
1038	1038-1039	1038	1038	1038	1038
1039	1039-1040	1039	1039	1039	1039
1040	1040-1041	1040	1040	1040	1040
1041	1041-1042	1041	1041	1041	1041
1042	1042-1043	1042	1042	1042	1042
1043	1043-1044	1043	1043	1043	1043
1044	1044-1045	1044	1044	1044	1044
1045	1045-1046	1045	1045	1045	1045
1046	1046-1047	1046	1046	1046	1046
1047	1047-1048	1047	1047	1047	1047
1048	1048-1049	1048	1048	1048	1048
1049	1049-1050	1049	1049	1049	1049
1050	1050-1051	1050	1050	1050	1050
1051	1051-1052	1051	1051	1051	1051
1052	1052-1053	1052	1052	1052	1052
1053	1053-1054	1053	1053	1053	1053
1054	1054-1055	1054	1054	1054	1054
1055	1055-1056	1055	1055	1055	1055
1056	1056-1057	1056	1056	1056	1056
1057	1057-1058	1057	1057	1057	1057
1058	1058-1059	1058	1058	1058	1058
1059	1059-1060	1059	1059	1059	1059
1060	1060-1061	1060	1060	1060	1060
1061	1061-1062	1061	1061	1061	1061
1062	1062-1063	1062	1062	1062	1062
1063	1063-1064	1063	1063	1063	1063
1064	1064-1065	1064	1064	1064	1064
1065	1065-1066	1065	1065	1065	1065
1066	1066-1067	1066	1066	1066	1066
1067	1067-1068	1067	1067	1067	1067
1068	1068-1069	1068	1068	1068	1068
1069	1069-1070	1069	1069	1069	1069
1070	1070-1071	1070	1070	1070	1070
1071	1071-1072	1071	1071	1071	1071
1072	1072-1073	1072	1072	1072	1072
1073	1073-1074	1073	1073	1073	1073
1074	1074-1075	1074	1074	1074	1074
1075	1075-1076	1075	1075	1075	1075
1076	1076-1077	1076	1076	1076	1076
1077	1077-1078	1077	1077	1077	1077
1078	1078-1079	1078	1078	1078	1078
1079	1079-1080	1079	1079	1079	1079
1080	1080-1081	1080	1080	1080	1080
1081	1081-1082	1081	1081	1081	1081
1082	1082-1083	1082	1082	1082	1082
1083	1083-1084	1083	1083	1083	1083
1084	1084-1085	1084	1084	1084	1084
1085	1085-1086	1085	1085	1085	1085
1086	1086-1087	1086	1086	1086	1086
1087	1087-1088	1087	1087	1087	1087
1088	1088-1089	1088	1088	1088	1088
1089	1089-1090	1089	1089	1089	1089
1090	1090-1091	1090	1090	1090	1090
1091	1091-1092	1091	1091	1091	1091
1092	1092-1093	1092	1092	1092	1092
1093	1093-1094	1093	1093	1093	1093
1094	1094-1095	1094	1094	1094	1094
1095	1095-1096	1095	1095	1095	1095
1096	1096-1097	1096	1096	1096	1096
1097	1097-1098	1097	1097	1097	1097
1098	1098-1099	1098	1098	1098	1098
1099	1099-1100	1099	1099	1099	1099
1100	1100-1101	1100	1100	1100	1100

Test No.	Location	Time	Wet Soil	Dry Soil	Observations
1101	1101-1102	1101	1101	1101	1101
1102	1102-1103	1102	1102	1102	1102
1103	1103-1104	1103	1103	1103	1103
1104	1104-1105	1104	1104	1104	1104
1105	1105-1106	1105	1105	1105	1105
1106	1106-1107	1106	1106	1106	1106
1107	1107-1108	1107	1107	1107	1107
1108	1108-1109	1108	1108	1108	1108
1109	1109-1110	1109	1109	1109	1109
1110	1110-1111	1110	1110	1110	1110
1111	1111-1112	1111	1111	1111	1111
1112	1112-1113	1112	1112	1112	1112
1113	1113-1114	1113	1113	1113	1113
1114	1114-1115	1114	1114	1114	1114
1115	1115-1116	1115	1115	1115	1115
1116	1116-1117	1116	1116	1116	1116
1117	1117-1118	1117	1117	1117	1117
1118	1118-1119	1118	1118	1118	1118
1119	1119-1120	1119	1119	1119	1119
1120	1120-1121	1120	1120	1120	1120
1121	1121-1122	1121	1121	1121	1121
1122	1122-1123	1122	1122	1122	1122
1123	1123-1124	1123	1123	1123	1123
1124	1124-1125	1124	1124	1124	1124
1125	1125-1126	1125	1125	1125	1125
1126	1126-1127	1126	1126	1126	1126
1127	1127-1128	1127	1127	1127	1127
1128	1128-1129	1128	1128	1128	1128
1129	1129-1130	1129	1129	1129	1129
1130	1130-1131	1130	1130	1130	1130
1131	1131-1132	1131	1131	1131	1131
1132	1132-1133	1132	1132	1132	1132
1133	1133-1134	1133	1133	1133	1133
1134	1134-1135	1134	1134	1134	1134
1135	1135-1136	1135	1135	1135	1135
1136	1136-1137	1136	1136	1136	1136
1137	1137-1138	1137	1137	1137	1137
1138	1138-1139	1138	1138	1138	1138
1139	1139-1140	1139	1139	1139	1139
1140	1140-1141	1140	1140	1140	1140
1141	1141-1142	1141	1141	1141	1141
1142	1142-1143	1142	1142	1142	1142
1143	1143-1144	1143	1143	1143	1143
1144	1144-1145	1144	1144	1144	1144
1145	1145-1146	1145	1145	1145	1145
1146	1146-1147	1146	1146	1146	1146
1147	1147-1148	1147	1147	1147	1147
1148	1148-1149	1148	1148	1148	1148
1149	1149-1150	1149	1149	1149	1149
1150	1150-1151	1150	1150	1150	1150
1151	1151-1152	1151	1151	1151	1151
1152	1152-1153	1152	1152	1152	1152
1153	1153-1154	1153	1153	1153	1153
1154	1154-1155	1154	1154	1154	1154
1155	1155-1156	1155	1155	1155	1155
1156	1156-1157	1156	1156	1156	1156
1157	1157-1158	1157	1157	1157	1157
1158	1158-1159	1158	1158	1158	1158
1159	1159-1160	1159	1159	1159	1159
1160	1160-1161	1160	1160	1160	1160
1161	1161-1162	1161	1161	1161	1161
1162	1162-1163	1162	1162	1162	1162
1163	1163-1164	1163	1163	1163	1163
1164	1164-1165	1164	1164	1164	1164
1165	1165-1166	1165	1165	1165	1165
1166	1166-1167	1166	1166	1166	1166
1167	1167-1168	1167	1167	1167	1167
1168	1168-1169	1168	1168	1168	1168
1169	1169-1170	1169	1169	1169	1169
1170	1170-1171	1170	1170	1170	1170
1171	1171-1172	1171	1171	1171	1171
1172	1172-1173	1172	1172	1172	1172
1173	1173-1174	1173	1173	1173	1173
1174	1174-1175	1174	1174	1174	1174
1175	1175-1176	1175	1175	1175	1175
1176	1176-1177	1176	1176	1176	1176
1177	1177-1178	1177	1177	1177	1177
1178	1178-1179	1178	1178	1178	1178
1179	1179-1180	1179	1179	1179	1179
1180	1180-1181	1180	1180	1180	1180
1181	1181-1182	1181	1181	1181	1181
1182	1182-1183	1182	1182	1182	1182
1183	1183-1184	1183	1183	1183	1183
1184	1184-1185	1184	1184	1184	1184
1185	1185-1186	1185	1185	1185	1185
1186	1186-1187	1186	1186	1186	1186
1187	1187-1188	1187	1187	1187	1187

<u>Test #23</u>	<u>Application</u>	<u>Test</u>
Date	12 Dec 1947	13 Dec 1947
Time	1500	1000
Wet Bulb	53° F	54° F
Dry Bulb	71° F	70° F
#Stresscoat Used	#1207	#1207
#Stresscoat Called For	#1202	
Time of Loading Specimen		(A) 70 sec (B) 25 sec

Temp of Specimen at time of coat failure: 70.5° F (A) & (B)

<u>Internal Pressure</u> <u>psi gage</u>	<u>Axial Load</u> <u>Lbs.</u>	<u>Strain Gage (micro inches)</u>			
		1	2	3	4
0	0	315/#8 ref	1260/#3	680/#5	1150/#6
(A) 0	36,580	970/#8	1050/#3	1300/#5	970/#6
0	0	320/#8	270/#4	680/#5	140/#7
(B) 1475	0	465/#8	860/#4	630/#5	745/#7

<u>Calibration</u> <u>Bar No.</u>	1A	1B	2A	3A	4A	4B	5	6
<u>Strain,</u> <u>Micro inches</u>	870	580	450	450	700	560	520	500
<u>Time of Loading</u> <u>Bar, Secs.</u>	1	1	70	1	70	1	25	25
<u>Bar Temperature,</u> <u>degrees F</u>	74.5	70.5	70.5	70.5	70.5	70.5	70.5	70.5

Remarks:

Specimen and bars were heated to approximately 80° F during the drying period and then allowed to assume room temperature prior to the test.

Test (B) was made after the crack pattern of part (A) had been obtained. Sufficient time for creep recovery of the coat was allowed between tests.

<u>Test #24</u>	<u>Application</u>	<u>Test</u>
Date	15 Dec 1947	16 Dec 1947
Time	1200	1000
Wet Bulb	54°F	58°F
Dry Bulb	73°F	76°F
#Stresscoat Used	#1208	#1208
#Stresscoat Called For	#1203	
Time of Loading Specimen		(A) 65 sec (B) 25 sec
Temp. of specimen at time coat failed:	76°F	

<u>Internal Pressure</u> <u>psi gage</u>	<u>Axial Load</u> <u>Lbs.</u>	<u>Strain Gage (micro inches)</u>			
		1	2	3	4
0	0	375/#8	1330/#3	725/#5	1200/#6
(A) 0	36,000	1045/#8	1155/#3	1360/#5	1050/#6
0	0	380/#8	360/#4	740/#5	230/#7
(B) 1625	0	540/#8	970/#4	885/#5	845/#7
0	0	425/#8	350/#4	720/#5	195/#7

<u>Calibration</u> <u>Bar No.</u>	1	2A	2B	3	4	5	6A*	6B*
<u>Strain,</u> <u>Micro Inches</u>	490	590	530	600	540	590	690	520
<u>Time of Loading</u> <u>Bar, Secs.</u>	1	65	1	65	1	25	25	1
<u>Bar Temperature,</u> <u>degrees F</u>	76	76	76	76	76	76	76	76

Remarks:

Bar #6 was crazed.

Test (B) was made after the crack pattern of Part (A) had been obtained. Sufficient time for creep recovery of the coat was allowed between tests.

Test No.	Location	Time
100	100	100
101	101	101
102	102	102
103	103	103
104	104	104
105	105	105
106	106	106
107	107	107
108	108	108
109	109	109
110	110	110

Time of location: 100

Interval	Location	Time
100	100	100
101	101	101
102	102	102
103	103	103
104	104	104
105	105	105
106	106	106
107	107	107
108	108	108
109	109	109
110	110	110

Location	Time
100	100
101	101
102	102
103	103
104	104
105	105
106	106
107	107
108	108
109	109
110	110

Time: 100

Time: 100

Time: 100

<u>Test #25</u>	<u>Application</u>	<u>Test</u>
Date	16 Dec 1947	17 Dec 1947
Time	1300	1400
Wet Bulb	58°F	56½°F
Dry Bulb	76°F	75°F
#Stresscoat Used	#1208	#1208
Time of Loading Specimen	(A) 35 sec (B) 28 sec	
Temp. of Specimen at time of coat failure:	76.5°F	

<u>Internal Pressure</u> <u>psi</u>	<u>Load</u> <u>Lbs.</u>	<u>Strain Gage (micro inches)</u>			
		1	2	3	4
0	0	385/#8	1270/#3	705/#5	1175/#6
(A) 0	34,000	940/#8	1095/#3	1285/#5	1010/#6
0	0	320/#8	290/#4	695/#5	180/#7
(B) 1330	0	470/#8	810/#4	850/#5	695/#7

<u>Calibration</u>	1	2A	3	4	5A	5B	6A	6B
<u>Bar No.</u>								
<u>Strain,</u> <u>Micro Inches</u>	530	580	500	540	530	620	540	540
<u>Time of Loading</u> <u>Bar, Secs.</u>	1	35	1	35	1	28	1	28
<u>Bar Temperature,</u> <u>degrees F</u>	76.5	76.5	75	75	75	75	75	75

Remarks:

All of the bars were slightly crazed both from drying and from low temperature. It so happened that the craze markings were indiscriminate in direction so that strain cracks could be readily seen. There was no craze on the specimen.

Test (B) was made after the crack pattern of Part (A) had been obtained. Sufficient time for creep recovery of the coat was allowed between tests.

Year	Location	Year	Year
1947	1947	1947	1947
1948	1948	1948	1948
1949	1949	1949	1949
1950	1950	1950	1950
1951	1951	1951	1951

Time of loading (hours) (1) 12 (2) 12 (3) 12

Temp. of loading (°F) (1) 12 (2) 12 (3) 12

Year	Location	Year	Year	Year	Year
1947	1947	1947	1947	1947	1947
1948	1948	1948	1948	1948	1948
1949	1949	1949	1949	1949	1949
1950	1950	1950	1950	1950	1950
1951	1951	1951	1951	1951	1951

Year	Location	Year	Year	Year	Year
1947	1947	1947	1947	1947	1947
1948	1948	1948	1948	1948	1948
1949	1949	1949	1949	1949	1949
1950	1950	1950	1950	1950	1950
1951	1951	1951	1951	1951	1951

Comments

All of the data were slightly revised from the original data for the following reasons. It was determined that the original data were inconsistent in the division of the data and could be readily seen. There was no change in the original data.

Year (1) was used after the original data were (1) and (2) were obtained. The original data for the year 1947 were also revised to 1947.

<u>Test #26</u>	<u>Application</u>	<u>Test</u>
Date	17 Dec 1947	18 Dec 1947
Time	1600	1300
Wet Bulb	56.5°F	58°F
Dry Bulb	75°F	74°F
Stresscoat Used	#1208	#1208
Time of Loading Specimen	(A) 50 sec (B) 35 sec	

Temp. of Specimen at time of coat failure: 75.5°F

<u>Internal Pressure</u> psi gage	<u>Axial Load</u> Lbs.	<u>Strain Gage (micro inches)</u>			
		1	2	3	4
0	0	370/#8	1315/#3	730/#5	1210/#6
(A) 0	37,000	1050/#8	1130/#3	1400/#5	1050/#6
0	0	400/#8	370/#4	770/#5	250/#7
(B) 1600	0	620/#8	1010/#4	940/#5	890/#7

Calibration Bar No.	1	2	3	4	5	6
Strain, Micro Inches	580	600	600	585	600	640
Time of Loading Bar, Secs.	1	50	50	35	35	35
Bar Temperature, degrees F	76.5	75.5	75.5	75.5	75.5	75.5

Remarks:

Bars badly crazed - Specimen had very little craze.

Test (B) was made after the crack pattern of part (A) had been obtained. Sufficient time for creep recovery of the coat was allowed between tests.

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remains critical to us.

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Initial state	Initial	Final
00000000	00000000	00000000
00000001	00000001	00000001
00000010	00000010	00000010
00000011	00000011	00000011
00000100	00000100	00000100
00000101	00000101	00000101
00000110	00000110	00000110
00000111	00000111	00000111
00001000	00001000	00001000
00001001	00001001	00001001
00001010	00001010	00001010
00001011	00001011	00001011
00001100	00001100	00001100
00001101	00001101	00001101
00001110	00001110	00001110
00001111	00001111	00001111
00010000	00010000	00010000
00010001	00010001	00010001
00010010	00010010	00010010
00010011	00010011	00010011
00010100	00010100	00010100
00010101	00010101	00010101
00010110	00010110	00010110
00010111	00010111	00010111
00011000	00011000	00011000
00011001	00011001	00011001
00011010	00011010	00011010
00011011	00011011	00011011
00011100	00011100	00011100
00011101	00011101	00011101
00011110	00011110	00011110
00011111	00011111	00011111
00100000	00100000	00100000
00100001	00100001	00100001
00100010	00100010	00100010
00100011	00100011	00100011
00100100	00100100	00100100
00100101	00100101	00100101
00100110	00100110	00100110
00100111	00100111	00100111
00101000	00101000	00101000
00101001	00101001	00101001
00101010	00101010	00101010
00101011	00101011	00101011
00101100	00101100	00101100
00101101	00101101	00101101
00101110	00101110	00101110
00101111	00101111	00101111
00110000	00110000	00110000
00110001	00110001	00110001
00110010	00110010	00110010
00110011	00110011	00110011
00110100	00110100	00110100
00110101	00110101	00110101
00110110	00110110	00110110
00110111	00110111	00110111
00111000	00111000	00111000
00111001	00111001	00111001
00111010	00111010	00111010
00111011	00111011	00111011
00111100	00111100	00111100
00111101	00111101	00111101
00111110	00111110	00111110
00111111	00111111	00111111
01000000	01000000	01000000
01000001	01000001	01000001
01000010	01000010	01000010
01000011	01000011	01000011
01000100	01000100	01000100
01000101	01000101	01000101
01000110	01000110	01000110
01000111	01000111	01000111
01001000	01001000	01001000
01001001	01001001	01001001
01001010	01001010	01001010
01001011	01001011	01001011
01001100	01001100	01001100
01001101	01001101	01001101
01001110	01001110	01001110
01001111	01001111	01001111
01010000	01010000	01010000
01010001	01010001	01010001
01010010	01010010	

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File	File	File	File
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Time of loading 200, 1997

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had been obtained. Sullivan had not been

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<u>Test #27</u>	<u>Application</u>	<u>Test</u>
Date	18 Dec 1947	19 Dec 1947
Time	1300	1500
Wet Bulb	58°F	57°F
Dry Bulb	74°F	74°F
#Stresscoat Used	#1207	#1207
Time of Loading Specimen	(A) 55 sec (B) 35 sec	

Temp. of Specimen at time of coat failure: 74°F

<u>Internal Pressure</u> <u>psi gage</u>	<u>Axial Load</u> <u>Lbs.</u>	<u>Strain Gage (micro inches)</u>			
		1	2	3	4
0	0	365/#8	1320/#3	735/#5	1200/#6
(A) 0	35,200	1045/#8	1150/#3	1340/#5	1030/#6
0	0	380/#8	345/#4	745/#5	225/#7
(A) 1600	0	570/#8	1000/#4	925/#5	860/#7

<u>Calibration</u> <u>Bar No.</u>	1	2	3	4	5A	6A	5B	6B
<u>Strain, Micro Inches</u>	570	580	580	570	550	540	550	490
<u>Time of Loading</u> <u>Bar, Secs.</u>	1	55	55	55	35	35	1	1
<u>Bar Temperature,</u> <u>degrees F</u>	74	74	74	74	74	74	74	74

TEST	TEST	TEST
1000	1000	1000
1000	1000	1000
1000	1000	1000
1000	1000	1000
1000	1000	1000

TEST	TEST	TEST	TEST	TEST	TEST
1000	1000	1000	1000	1000	1000
1000	1000	1000	1000	1000	1000
1000	1000	1000	1000	1000	1000
1000	1000	1000	1000	1000	1000
1000	1000	1000	1000	1000	1000

TEST	TEST	TEST	TEST	TEST	TEST	TEST	TEST	TEST	TEST
1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

<u>Test #28</u>	<u>Application</u>	<u>Test</u>
Date	19 Dec 1947	20 Dec 1947
Time	1600	1000
Wet Bulb	57°F	56°F
Dry Bulb	74°F	72.5°F
Stresscoat Used	#1205	#1205

<u>Calibration</u> <u>Bar No.</u>	1	2	3	4	5	6	7	8	9	10
Strain, <u>Micro Inches</u>	680	620	630	780	820	850	700	630	620	600
Time of Loading Bar <u>Secs.</u>	30	30	30	30	30	30	30	1	1	1
Bar Temperature, de- <u>grees F</u>	72.5	72.5	72.5	72.5	72.5	72.5	72.5	72.5	72.5	72.5

Remarks:

Bars #4, #5, #6 were purposely crazed by exposure to cool air and then were allowed to return to room temperature.

The average Stresscoat thickness on each of the ten bars tested was between .0065" and .0075".

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